AD-A147 668 STRATEGIC MATERIALS: A CRISIS WAITING TO HAPPEN(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYSTEMS AND LOGISTICS T P LONG ET AL. SEP 84 1/2

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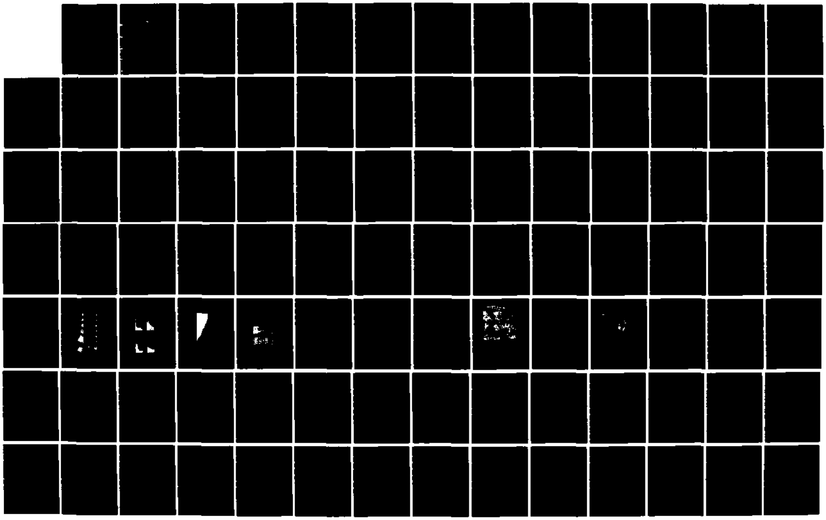

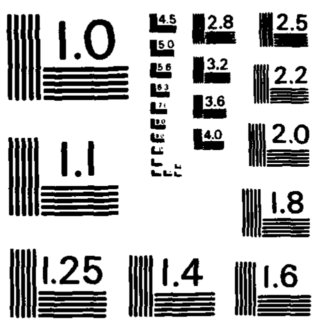

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

STRATEGIC MATERIALS:
A CRISIS WAITING TO HAPPEN

THESIS

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AFIT/GLM/LSM/84S-40

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AFIT/GLM/LSM/84S-40

STRATEGIC MATERIALS: A CRISIS WAITING TO HAPPEN

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Logistics Management

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September 1984

Acknowledgments

We wish to express our sincere appreciation to those individuals who have contributed their suggestions, co-operation, and support to this effort. Their contributions have made this document possible.

A special thanks is extended to our thesis advisor, Dr. William C. Pursch, whose dedicated guidance and enthusiasm made this educational endeavor an exciting and enjoyable experience.

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Abstract

The United States is dependent on foreign sources for many strategic materials vital to its survival and national security. This study reviews past and present policies on the stockpiling of strategic materials, the quality of stockpiled materials, and examines the position and role of the Soviet Union in denying the U.S. access to strategic materials. It provides a close examination of cobalt, chromium, manganese, and titanium, their importance to the defense industry and the possible impact of a material shortage on the U.S. economy and national security. To reduce America's vulnerability, a policy that integrates strategic materials, national security, foreign policy, and economic issues should be implemented. Specific findings and recommendations are presented at the end of the study.

STRATEGIC MATERIALS: A CRISIS WAITING TO HAPPEN

I. Introduction

> The commuter slipped behind the wheel of his Detroit built sedan. Switching on the ignition system built with Zambian copper and Ghanain aluminum, he drew power from a battery made of Missouri lead and South African antimony to start an engine of Pittsburgh steel strengthened by South African manganese and hardened with chrome from Zimbabwe. The car rolled on tire treads blended from natural rubber from an Algerian photochemical base. The exhaust from Nigerian gasoline was cleansed by Russian platinum. The commuter switched on the radio with invisible traces of cobalt from Zaire and tantalum from Mozambique heard a newscaster's report of a Communist led cou in a small country in southern Africa. What's tha to me, he thought switching to a station carrying the latest sports results [54:1].
>
> James Sinclair
> The Strategic Metals War 1983

Background and Justification

The United States is one of the most powerful nations in the world, with only the Soviet Union considered an equal in terms of military strength. Among its obligations, the United States government must protect and defend its citizens. This and other responsibilities are reflected in our nation's vital interests:

> To preserve our freedom, our political identity, and the institutions that are their foundation -- the Constitution and the rule of law.
>
> To protect the territory of the United States, its

> citizens, and its vital interests abroad from armed attack.
>
> To foster an international order supportive of the interests of the United States through alliances and cooperative relationships with friendly nations; and by encouraging democratic institutions, economic development, and self-determination throughout the world.
>
> To protect access to foreign markets and overseas resources in order to maintain the strength of the United States' industrial, agricultural, and technological base and the nation's economic well-being [7:15].

The U.S. military serves as one of many instruments the President has at his disposal to protect our vital interests from menacing foreign sovereignties. Any modern nation supporting a large, modern, and ready military force has to draw heavily from its agricultural, economic, technological, and industrial bases. These bases in turn depend on natural resources (minerals) within and beyond the borders of the United States. The health and strength of these bases often determine the military strength of a nation and the nation's ultimate survival.

The importance of these minerals cannot be understated, for they are absolutely essential to the health of the U.S. economy and the U.S. military. The industrial base of the United States requires vast amounts of these minerals in various forms:

> Minerals are essential for national defense, to sustain high agricultural productivity, and to achieve national goals for the supply and conservation of energy. Minerals and the technologies they present are needed for the preservation of a healthy environment. Minerals are a major component of international trade and

therefore are an important factor in our relations with foreign countries [13:1].

The very existence of the United States is dependent upon the availability of what has become known as strategic and critical minerals. No modern nation can survive without these minerals.

In 1982, the 3.1 trillion U.S. economy required (43:2):

$ 90	Billion Domestic Crude Oil	
41	Billion Imported Crude Oil	
17	Billion Imported Refined Petroleum	
45	Billion Domestic Natural Gas	
23	Billion Domestic Coal	
1	Billion Domestic Uranium Ore	
196	Billion Domestic Nonfuel Minerals	
	derived from domestic raw minerals	$20 billion
	domestic old scrap	4 billion
	imported raw minerals	4 billion
94	Billion Imported Processed Nonfuel Minerals.	

Without these minerals our standard of living and our society would be severely threatened. Reduction in just four metals (manganese, chromium, platinum, and cobalt) would cause a disastrous slowdown in the basic industries of; transportation, manufacturing, construction, electronics, aerospace, and even agriculture. The rippling effect would throw untold millions of Americans out of work, cause inflation to skyrocket, and make the dollar worthless. The results would be political and economic chaos (58:138).

With so much at stake let us not forget the words of British Air Marshall Sir John Slessar (20:9) who said, "...There is a tendency to forget that the most important social service that a government can do for its people is to keep them alive and free."

Statement of the Problem

The United States is recognized as a superpower today because of its industrial base. One reason the U.S. became a superpower was because of its self-sufficiency in energy and raw materials. However, at the turn of the century the U.S. began moving away from self sufficiency in raw materials. At present the U.S. is dangerously dependent on other nations to provide many of the strategic minerals and materials vital to our national security and economic survival. Foreign sources now provide 22 out of 36 nonfuel minerals essential to the industrial base (63:85). Many of the nations supplying these minerals are communist aligned or located in the very unstable regions of Africa. The U.S. stockpiles of materials are grossly below wartime and contingency requirements as set by the 1979 Stockpiling Act. The impact of a prolonged interruption of these materials would have a devastating effect upon the economy and defense of the free world.

Definitions

Since the following concepts will be used extensively throughout this report, a clarification of their meaning must precede further discussion.

National Emergency: A general declaration of emergency with respect to the national defense made by the President or by the Congress (63:3).

Strategic and Critical Materials: Materials or minerals that would be needed to supply the military, industrial, and essential civilian needs of the United States during a national emergency and which are not found or produced in the United States in sufficient quantities to meet such a need (63:3).

National Defense Stockpile: Is intended to Support defense production and essential civilian needs with critical and strategic minerals and materials during a national emergency (9:12).

Objectives of the Research

The objectives of this research are to:

1. Evaluate the ability of our national defense stockpile to mitigate the effects of an indefinite interruption of strategic materials.

2. Identify the effects of a prolonged cutoff of four selected strategic minerals (chromium, cobalt, manganese, and titanium) on the defense industrial base.

Research Questions

In determining the answer to the first objective we asked and answered the following research questions:

1. Has the evolutionary development of the National Defense Stockpile been consistent with the external threats?

2. Does an adequate national policy on strategic and critical materials exist today?

3. What is the current status of the National Defense Stockpile?

We examined the research questions below to determine the answer to the second research objective:

1. What threats do we face today that require the United States to stockpile critical materials?

2. What role does cobalt, chromium, manganese, and titanium play in our national defense and U.S. economy?

3. Are the primary users of these materials prepared to face a prolonged interception of materials?

4. What short term and long term substitution possibilities exist for the study materials?

II. Methodology

Overview

The previous chapter introduced the background material and the objectives of this research project. This chapter will outline the methodology used to research and evaluate the material introduced in the earlier chapters. The objectives of this thesis will be accomplished through review and evaluation of the current literature and a structured interview technique. This chapter will be broken down into three sections: Information Collection, Information Analysis, and Research Limitations. The information collection section which indicates the sources and methods of information collection is presented first. The analysis section will deal with the methods used to analyze the information collected and complete the research objectives stated in chapter one. The last section to be covered will identify limitations concerning the research and information gathering methods.

Information Collection

The most recent background material was collected through an extensive search of the literature base for applicable studies and articles pertaining to strategic and critical materials and minerals. Research material was obtained through the Defense Technical Information Center (DTIC), AFIT School of Systems and Logistics Library, Wright

State University Library, and the Office of Legislative Affairs (Air Force Section). In addition, information was requested and obtained from the following U.S. Government Agencies: Bureau of Mines, Department of Commerce, Defense Intelligence Agency, Federal Emergency Management Agency, Central Intelligence Agency, Government Services Administration (Stockpile Management Section), Government Printing Office, Office of Industrial Base Assessment, and the Government Accounting Office.

Additional research information will be obtained through discussions with government officials and executives in private industry that are involved in managing strategic and critical materials and minerals. Structured telephone and personal interviews should provide a valuable insight into the problems and issues currently affecting the Defense Industry and the National Defense Stockpile concerning strategic and critical materials and minerals. See Appendix D for a list of interviewee questions.

Information Analysis

The goal of the information analysis section was to meet the research objectives previously listed in Chapter 1.

The first objective, "Evaluate the ability of our National Defense Stockpile to mitigate the effects of a strategic materials cutoff," was accomplished through an extensive review of the literature and structured interviews with managers of the National Defense Stockpile.

In determining the answer to the first objective, we answered the following research questions:

1. Has the evolutionary development of the National Defense Stockpile been consistent with the external threats?

2. Does an adequate national policy on strategic and critical materials exist today?

3. What is the current status of the National Defense Stockpile?

The second objective, "to identify the impact of a prolonged interruption of four selected strategic materials on the defense posture of the United States," was again answered through an extensive literature review and telephone interviews with defense industry officials.

We examined the research questions below to determine the answer to the second objective:

1. What threats do we face today that require the United States to stockpile critical materials?

2. What role does cobalt, chromium, manganese, and titanium play in our national defense and U.S. economy?

3. Are the primary users of these materials prepared to face a prolonged interruption of materials?

4. What short term and long term substitution possibilities exist for the study materials?

<u>Research Limitations</u>

Although there is classified information available applicable to our research effort, none was integrated into

this report because of the difficulty involved in obtaining and using classified material. It is likely that classified material would have enhanced portions of the report; however, we believe this report will not suffer for lack of it.

Additional limitations include our inability to have an official survey instrument approved by the Office of Management and Budget because of time constraints and the reluctance of many leading industrial companies to provide information helpful to our effort. And of those who did, they were reluctant to be identified or have their company identified in the final report.

III. Literature Review

History of Stockpiling of Strategic and Critical Materials and Minerals

The United States grew rapidly from a colony to an industrialized nation largely because of its self-sufficiency due to abundant energy and raw materials (45:2). At the time of the Revolutionary War, the annual per capita use of minerals in the colonies was about 1200 pounds. This use consisted of 1000 pounds of sand and gravel, 112 pounds of brick and lime, 40 pounds of coal, and 20 pounds of iron. The remainder consisted of copper, glass, lead, potash, salt, nitrates, sulfur, and zinc. Within 200 years the population grew from 2.5 million to 220 million and the annual consumption increased to 41,000 pounds per person. Currently, it takes more than four billion tons of new materials each year to sustain the U.S. economy (12:76).

President Theodore Roosevelt's Administration was the first to review critical materials and their importance. He established the National Conservation Commission in 1909. The Commission predicted that domestic sources of petroleum and high-grade ore would be depleted by the middle of the century; although ideas for solving the possible dilemma were discussed, no permanent action was taken by the Congress or the Executive Branch (27:6). The difficulties of obtaining critical materials became more apparent during World War I, and as a result, in 1921 the Army General Staff

started planning a critical materials stockpile to help meet future wartime requirements (45:88). Then, in 1921 the War Department studied those critical materials in short supply during World War I. The War Department then published the Harbard List which cited 28 different minerals necessary in future wars. Once again, no real action was taken by the authorities to stockpile until war returned to Europe in 1939 (27:6). The first stockpile was established during the mobilization period before World War II when the National Stockpile was created by the Strategic and Critical Materials Stockpiling Act of June 7, 1939 (12:230). At that time, Congress appropriated ten million dollars (27:6) for the purchase of materials for the stockpile, but the set goals were not achieved, and the stockpile was quickly eliminated during the early stages of the war. Other related actions which took place during the war involved the expansion of the minerals industries. President Roosevelt designated more than 100 different minerals and metals as essential to war. As a result, the aluminum output tripled from 1942-1944, magnesium production increased 50 times within 5 years, and steel production was one third higher in 1944 than in 1940. In addition, large quantities of tungsten, mercury, and chrome were also obtained. By focusing on the production of critical materials, the United States produced 45% of all the combat munitions and arms used in 1944 (27:7). President Truman reflected on the supply problems encountered during World War II when he

addressed Congress in 1946:

> The development of our natural resources is.......startling. We have torn from the earth copper, iron ore, tungsten, and every mineral required to fight a war, without regard to our future supplies. We have taken what we needed. We were not able to, and we did not, take account of tomorrow [27:7].

To more effectively plan for future national emergencies, the Strategic and Critical Materials Stockpiling Act of 1939 was reviewed, and subsequently replaced by the Strategic and Critical Materials Stockpiling Act Amendment of 1946. This new law sought to improve domestic production and expand the stockpile of strategic and critical materials not already present in sufficient quantities to meet national security requirements (45:88). The Amendments were deemed necessary because of the shortages and disruptions in rubber, tin, tungsten, copper, and other essential materials experienced during World War II. New legislation encouraged the development of new mines and deposits of certain critical materials (12:230).

Congress passed the Defense Production Act of 1950 to stimulate the rapid expansion of our nation's industrial capacity during the Korean Conflict (36:61). Not only did it provide for the expanded production of military material and equipment during a crisis, but the Defense Production Act also authorized Government purchases of metals, minerals, and materials to stimulate the defense-related expansion of production capacity (12:230). It also authorized the President to institute preparedness programs

to improve the industrial base and to prepare for national defense mobilization programs. The Defense Production Act, originally intended to last until 1952, has been extended by 31 public laws and is still in effect today. It provides for the following: Title 1: The assignment of priorities and allocations of defense materials; Title 2: The authorization to requisition strategic materials and facilities; and Title 3: The authorization to help finance improvements and expansion of production capacity and supply (45:89).

On January 22, 1951, the President's Materials Policy Commission was created by Executive Order of President Harry Truman. The Commission investigated five major areas: The long-range requirements outlook; the long-range supply outlook; the estimated extent of shortages of strategic materials; the consistency and adequacy of existing Government policies, plans, and programs; and the consistency and adequacy of private industry practices. The Commission later became known as the "Paley Commission." The Paley Commission was formed at a time in history when we had scarcely recovered from World War I and World War II, yet at the same time we found ourselves faced with the demand for material requirements to support the Korean War. The Paley Commission addressed our wartime demands and also the peacetime requirements of a growing economy (12:32-33).

> By the midpoint of the 20th Century we had...completed our slow transition from a raw

> materials surplus nation to a raw materials deficit nation [12:34].

The Commission turned their attention to different ways we could promote the development and more effective use of our domestic resources. They suggested that the United States increase exploration, find less wasteful ways to use known resources, increase the development of lower quality resources, use renewable resources more widely, develop new synthetic materials, produce materials that last longer, and finally increase the use of recovery and recycling (12:34). The Paley Commission addressed directly the Nation's growing reliance on imported materials from abroad. It rejected total self-sufficiency, even for the sake of national security, as dangerous; instead, the Commission favored the least cost principle. Nevertheless, the Commission expressed concern over import-dependence and its possible effect on our strategic concerns. As a result, they recommended the stockpiling of strategic materials when "an economically-viable domestic industry could not be sustained [12:35]."

Two of the most important recommendations made by the the Paley Commission, also known as the President's Materials Policy Commission, were as follows:

> First, the analytical capability of government must be strengthened from top to bottom, and second, the dimensions of the issues require direction by a policy group within the Executive Office of the President [27:10].

These recommendations were implemented 26 years later with

the adoption of the Strategic and Critical Materials Stockpiling Act of 1979 (27:10) which will be discussed in more detail later.

> Overall, what our experience during the Korean Conflict and two world wars has taught us is that the singularly important difference between a peacetime and a wartime economy is the degree to which the industrial base can respond to unanticipated wartime demands. Otherwise, the requirements for a smoothly functioning economy during peace and during war are similar. Both depend upon an industrial base that reflects planning and established priorities. Both require an existing military strength, maximum employment, and adequate purchasing power. Neither can function without ready supplies of virtually every known raw material [43:19].

After World War II, the U.S. stockpile was to retain sufficient quantities of strategic materials to last through a five-year conflict requiring a military force of ten million, but in 1958 this was changed to a three-year period requiring a force of five million (12:233). The need for raw materials was not as obvious, and the lessons learned during World War I and World War II had been forgotten (27:10). Taking this attitude into account, note that from 1966-1968 there were major releases of stockpile materials. The Vietnam War was being fought, and the sale of surplus items from the stockpile was motivated by economics rather than national security. The principal minerals sold were copper and nickel. With Copper in short supply during the Vietnam Conflict period, industry experienced sharply rising prices. Therefore, the President ordered the release of copper to defense contractors to ease price increases and to

provide more materials for war. The nickel was released because of an ongoing strike in Canada, which at that time was the major producer of nickel. These minerals were never replaced (27:10).

Title II of the National Materials Policy Act of 1970 created the National Commission on Materials Policy. Its purpose was to enhance the quality of the environment and to conserve materials in anticipation of future requirements of our Nation and the world. The Commission made recommendations on supply, use, recovery, and disposal of strategic materials. On June 27, 1973, the Commission transmitted to the President and Congress a report entitled, "Materials Needs and the Environment Today and Tomorrow." The paper addressed the issue of how current and future materials needs could be met while still maintaining or improving the environmental quality (12:35). The report emphasized interrelationships between materials, energy, and the environment; in other words, issues involving one of these should be considered as involving all. The Commission noted that the United States was more autonomous than any major industrial country in the world except the Soviet Union, and that we imported most materials not because we lacked materials but because we could buy elsewhere at a more reasonable cost. They reaffirmed the "least cost principle" of the Paley Commission and made the following conclusion:

...in the interest of national security, it is

> unwise to become import dependent upon specific strategic commodities for which the United States lacks a resource base and which are obtained mainly from a small number of countries which may choose to restrict or cut off the flow of supply ... The interest of the national security will be served by maintaining access to a reasonable number of diverse suppliers for as many materials as possible [12:36].

The Commission made the following recommendations to reduce import dependency:

1. Foster the expansion of domestic production.
2. Diversify the sources of supply.
3. Develop special relations with reliable sources.
4. Find substitutes and develop synthetics.
5. Increase the dependence of supplying countries upon U.S. goodwill.
6. Allocate present supplies through priority use.

As a result of reports like the one submitted by the National Commission on Materials Policy, numerous pieces of legislation were passed on water and air quality standards. Many domestic suppliers of strategic materials found it too expensive to meet EPA standards, and the mining industry was no exception. The average industry spends six percent of its capital expenditures on pollution control equipment but the non-ferrous metals mining industry spends about nineteen percent. As a result, the mining industry tried to reduce their costs by using more economical foreign material resources (45:3). From 1971-1973 hundreds of mines and smelters closed down or moved to foreign countries because of the strict environmental and health standards. Vast

public lands were closed to mining companies; for example, in 1968 seventeen percent of public lands were closed to mining but by 1974 sixty-seven percent had closed. These events prompted a shortage of minerals in the United States; to overcome the situation minerals were sold out of the National Defense Stockpile to offset high trade deficits created by the Arab Oil Crisis (27:12).

On April 16, 1973, President Nixon reduced the National Strategic Stockpile to reflect planning for a one-year conflict. His reasons follow: The world outlook was more peaceful, improved technology made substitution of scarce materials easier, defense needs could be met through the civilian sector, and a one-year emergency would give adequate time for mobilization (12:233). Large quantities of chromium, manganese, aluminum, copper, and cobalt were sold. For example, in 1972 the National Stockpile contained 68 million pounds of cobalt; but by December 31, 1975, the stockpile contained only 45 million pounds. The sale of the excess strategic materials helped to maintain price control and price stabilization efforts during a time when the United States was broke and deeply in debt (63:89). On March 5, 1975, the Subcommittee on Seapower and Strategic and Critical Materials of the House Committee on Armed Services voted to authorize no further disposals of stockpile materials until a new policy study was performed. In response, on October 1, 1976, the Ford Administration announced a major new long-range program of acquisition and

disposals for the stockpile based on the first three years of an emergency of indefinite duration. Goals increased for 72 of the 93 stockpiled materials (12:233). President Carter's Administration reviewed and reaffirmed the Ford Administration's policy in October of 1977 but the allocation of funds for the purchase of new materials did not follow. In fact, no large amount of money had been allocated since 1960 (27:13).

Concern over the condition of our National Stockpile prompted Congress to pass the Strategic and Critical Materials Stockpiling Revision Act of 1979 (45:90). During the prior two decades, the policy on the stockpile had sharply fluctuated as the administrations had changed. The stockpile had been reduced from a five-year contingency level, to a three-year level, and then to a one-year level (12:68). The Strategic and Critical Materials Stockpiling Act of 1939 was very much out of date, and the many modifications and provisions were confusing and conflicting (12:69). The Strategic and Critical Materials Stockpiling Revision Act of 1979 was the result of a two-year review of U.S. mineral policies which sought to correct deficiencies identified over the past 25-year period (27:13).

The major aspects of the Strategic and Critical Materials Stockpiling Revision Act follow: 1. Stockpiles would only be used for the defense of the United States and not to influence commodity prices. 2. Goals were set at a three-year contingency level. 3. The President would be

responsible for managing the Stockpile (45:90-91) and for determining the materials, their quality, and quantity (12:241). Another important aspect of the Act strengthened the legislative role of Congress in stockpile matters (12:69); for instance, all disposals now require Congressional approval, and stockpile goals cannot be changed without prior written notice to Congress listing the details and reasons for the proposed changes (12:233). This act also placed into the National Defense Stockpile all materials obtained and separately inventoried under all previous acts (12:231). For example, the Stockpile Revision Act combined the Defense Production Inventory and the Supplemental Stockpile with the National Stockpile. The President assigned stockpile planning and oversight activities to the Director of the Federal Emergency Management Agency (FEMA). The Office of Plans and Preparedness within the agency has the responsibility of developing guidelines for stockpiling strategic materials and for periodically reviewing the stockpile goals. Management functions were delegated to the General Services Administration (GSA) and placed under the Federal Property Resources Service within the GSA (12:241). Finally, each year a list of goals, deficits, excesses, and priorities are developed and assessed according to market conditions to determine quantities to be bought and sold without disrupting the market. The list, also known as the Annual Materials Plan (AMP), is submitted to Congress as part of

the President's budget each year (12:243).

Until 1979 no significant national policy on the issue of the National Stockpile existed, so in 1980 a bill was passed to establish an overall national minerals policy. The National Materials and Minerals Policy, Research and Development Act required the President to submit to Congress annually a report on strategic materials. The major emphasis of the report focused on the problems associated with shortages or supply disruptions (45:92). This bill tasked the Office of Science and Technology Policy; the Secretaries of Commerce, Interior, and Defense; the Federal Emergency Management Administration; and the Director of the CIA to work together to create reports concerning strategic materials and minerals (45:92). "It was at least a first attempt to communicate between all the players interested in a national materials policy [45:92]."

The most recent piece of legislation passed is the Critical Materials Act of 1982 which establishes a Council on Critical Materials. Its tasks are to coordinate all materials policy between various government agencies and departments, to publicize the importance of strategic materials to Congress and the public, and to consult with private industry on strategic materials related issues (45:92). "If the bill translates these ideas into reality, a great deal will have been accomplished in correcting some of the deficiencies of the stockpile management of the 1970's [45:92]."

Conclusion

This section reviewed the evolution of the stockpile's content, role, and management, and showed how past U.S. policy has often been one of reaction rather than deliberate planning. Initially, in a developing country one may expect to find this. However, the need for and the importance of strategic materials was clearly identified during World War I, yet, no action was taken until war returned to Europe in 1939. The history of the stockpile shows several times how we have identified the importance of and need for many materials but have failed to effectively plan for interruption. The U.S. was fortunate during World War II in its ability to maintain adequate supplies of strategic materials located beyond its borders.

History also shows how the requirements of the stockpile and its susceptability to political influence have changed. As technology and weapon requirements have changed, so have the materials in the stockpile. More exotic, stronger, flexible, and temperature resistant materials have replaced the basic materials of the earlier stockpiles.

As administrations changed, so did the role of the stockpile. Its requirements to meet national needs changed from five years, to three years, to one year, and back to three years. It has been susceptible to political influence by the selling of "excess stockpiled material" to balance the federal budget. Some of those materials sold are now short of their required goal and will be very costly

to replace at current prices.

Though the evolution of the stockpile has been consistent with external threats to the United States, it has not been a deliberate planned change. The imports of strategic materials and minerals to the defense industry must be realized not only during a crisis, but also before a crisis, when there is adequate time for preparation.

Present National Policy and Status of the National Defense Stockpile (NDS)

Present National Policy.

The need for a national materials policy, embracing forces beyond the economic market place, has been the subject of debate for over thirty years. The Paley Commission, previously discussed, was the first to recommend a comprehensive policy. The present national policy on strategic materials has its foundation in Public Law 96-479 National Materials and Minerals Policy, Research and Development Act of 1980.

This act, signed into law October 21, 1980 by President Carter, contains many of the Paley Commission recommendations. The specific purpose of the act is:

> to promote an adequate and stable supply of materials necessary to maintain national security, economic well being, and industrial production with appropriate attention to achieving a long term balance between energy needs, a healthy environment, natural resources conservation, and social needs [12:71].

This was the first step towards a real national policy on strategic and critical materials. The law requires the

President to submit an annual plan to Congress which should provide a suitable mechanism for the following:

> Policy analysis and decision determination within the Executive Office of the President;
>
> Continuing long range analysis of materials use to meet national security economic, industrial and social needs; the adequacy and stability of supplies; and the industrial and economic implications of supply shortages or disruptions;
>
> Continuing private sector consultation and federal materials programs; and
>
> Interagency coordination at the level of the President's Cabinet [12:71].

The Reagan Administration submitted the required report entitled, <u>National Materials and Minerals Program Plan and Report to Congress</u>, on April 5, 1982. It is the policy of the Reagan Administration to:

> decrease America's mineral vulnerability by taking positive action that will promote our national security, help ensure a healthy and vigorous economy, create American jobs, and protect America's natural resources and environment [51:1].

President Reagan initiated adhoc committees and task forces to suggest administrative and legislative actions to help reduce our dependency and vulnerability. Some of the actions initiated include (51:2-5).

> The stimulation of private research and development to ensure the availability of materials essential to the nations economy and national defense.
>
> The review and reform of excessively burdensome or unnecessary regulations and statutes which adversely affect the domestic minerals industry.
>
> Directing a panel of experts to review the quality of materials in the stockpile and recommend such actions as necessary to ensure the quality of the stockpile.

> Ensuring high level consideration of important materials policy issues will be coordinated through the cabinet council on Natural Resources and Environment.
>
> Directing his administration to stimulate federal land availability.

His administration will rely primarily upon the NDS to provide for national defense objectives. Purchases of materials to meet the present stockpile goal will be made on the open market. The report intends that:

> these steps will begin to focus the attention of the nation on those specific mineral availability and processing problems that are posed to our economy and our national security by dependence on insecure sources where useable substitutes are not readily available [51:1].

President Reagan is the first President in over twenty years to take positive steps in reducing America's vulnerability to a minerals supply disruption. Even before his election, he expressed his concern over the increasing dependence of the United States on foreign sources for several strategic and critical materials. He also expressed concern over the state of the NDS and the ability of Americans to produce and supply many of these vital resources.

He initiated the first major purchase of strategic materials for the NDS in over twenty years. He called for the expenditure of $100 million; of which $78 million went for the purchase of cobalt (51:1). Some of the recent additions to the stockpile include one million tons of bauxite, 600 ounces of iridium, and 398 tons of rubber.

As stated earlier, the purpose of the NDS is to meet the military and essential civilian needs in time of mobilization or declared national emergency for a period of no less than three years. The use of stockpile material for economic or budgetary purposes has been specifically prohibited. At this point, it would be useful to examine the contents, status of minerals, determination of stockpile goals, and quality and form considerations.

<u>Contents and Status of the National Defense Stockpile</u>.

The NDS provides the cornerstone of the U.S. minerals policy. The NDS provides against a dangerous and costly dependence on foreign strategic and critical materials during an emergency. It consists of 93 commodities, 80 of which are mineral origin and the remainder are agricultural products. Specific goals have been set for 64 of the 80 mineral commodities. These 64 commodities represent 34 different minerals in various forms and stages of processing (21:7-8). Appendix A provides an explanation and detailed listing of all commodities in the stockpile, its inventory level, goal, and value. Figure 1 provides a capsulized summary of stockpile goals met.

Many of the materials in the stockpile exceed their goals. However, these surpluses were accumulated in the previous decades and many resulted by reducing inventory goals (38:25).

Today, the stockpile is valued at $11.1 billion, of

which $4.1 billion represents excess inventories. To meet all stated stockpile goals will require the addition of $9.8 billion of inventory. The total value of the stockpile would then be worth $16.8 billion. At the present appropriation levels existing today ($100 million), Paul Krueger of the Federal Emergency Management Agency, in testimony before the Congress, stated it would take 100 years to achieve existing stockpile goals (59:57). Unfortunately, the Reagan Administration has been neither successful nor

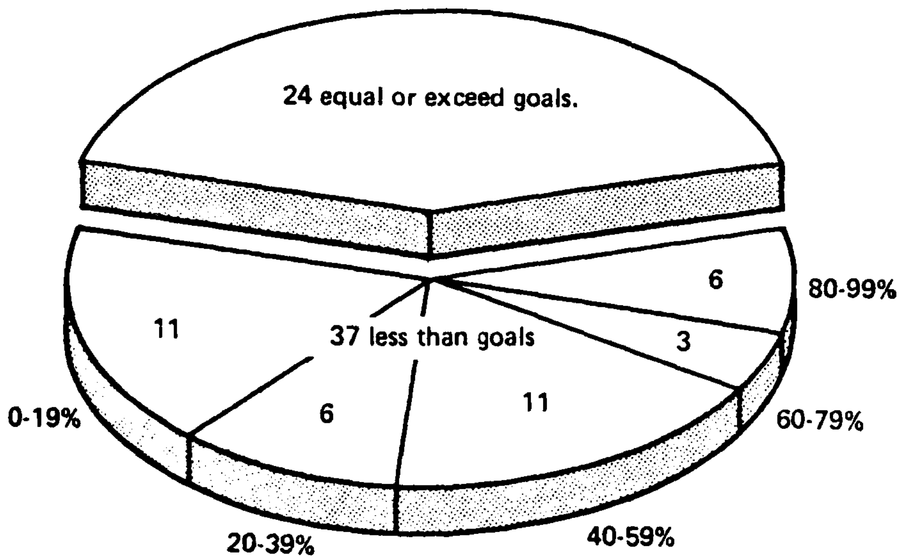


Fig 1. Percent of Stockpile Goals Filled. Source (22:4)

Table I

Stockpile Requirements Met For Study Materials

Material	Unit	Goal	Inventory	% Inv. Met
Chromium..........	ST Cr Metal	1,353,000	1,324,2123	97.9
Chromite, Chemical Grade Ore.........	SDT	675,000	242,414	35.9
Chromite, Metal-lurgical Grade Ore	SDT	3,200,000	2,488,043	77.7
Chromium, Ferro High Carbon.......	ST	185,000	402,696	217.6
Chromium, Ferro Low Carbon........	ST	75,000	318,892	425.1
Chromium, Ferro Silicon...........	ST	90,000	58,357	64.8
Chromium, Metal...	ST	20,000	3,763	18.8
Cobalt............	LB Co	85,400,000	45,995,714	53.8
Manganese.........	ST Mn Metal	1,500,000	1,958,966	130.6
Manganese Ore Chemical Grade....	SDT	170,000	194,653	114.5
Manganese Ore Metal-lurgical Grade....	SDT	2,700,000	3,367,103	124.7
Manganese, Ferro High Carbon	ST	439,000	599,978	136.6
Manganese, Ferro Low Carbon........	ST	0	0	NA
Manganese, Ferro Medium Carbon.....	ST	0	28,920	NA
Manganese, Silicon	ST	0	23,574	NA
Manganese, Metal Electrolytic......	ST	0	14,172	NA
Rutile............	SDT	106,000	39,186	36.9
Titanium Sponge...	ST	195,000	32,331	16.5

Source (6:17-19)

aggressive in increasing the funding levels for the purchase of needed minerals.

Determination of Stockpile Goals.

The Federal Emergency Management Agency uses a complicated econometric model to estimate the needs of a wartime economy. These requirements are broken into three separate economic sectors explained below (21:3).

> Defense - All production necessary to obtain weapons, manpower, and support, including the production of that segment of the population in support of the war or emergency.
>
> Essential Civilian - Those expenditures necessary to maintain the health, safety, morale, and productivity of that segment of the population in support of the war or emergency.
>
> General Civilian - Those expenditures, which after belt tightening, are necessary to support the population and maintain a viable industrial base.

This division of the economy into three sectors allows for national priorities to better reflect material requirements.

Figures 2 and 2a provide a flow chart description of the stockpile determination process.

Demand Requirements.

Starting with projections of a peacetime Gross National Product (GNP) in the wartime period, various factors are introduced into the model to reflect the economy in both peace time and wartime. In addition, to the normal policy instruments such as interest rates, corporate tax rates, etc., a number of other planning factors are introduced.

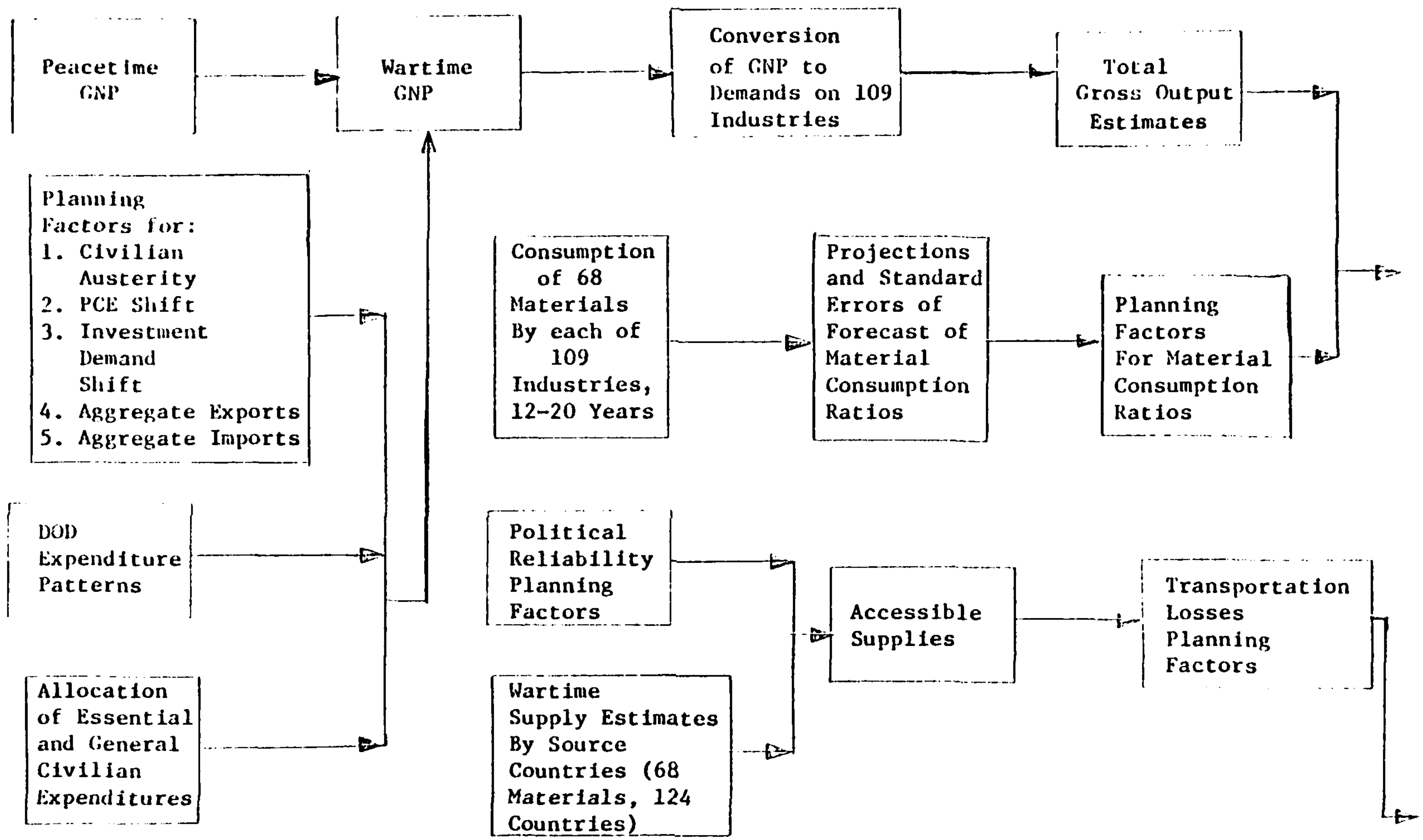


Fig 2. Stockpile Goal Estimation Methodology
(Once for Each Year, Once for Each Tier)

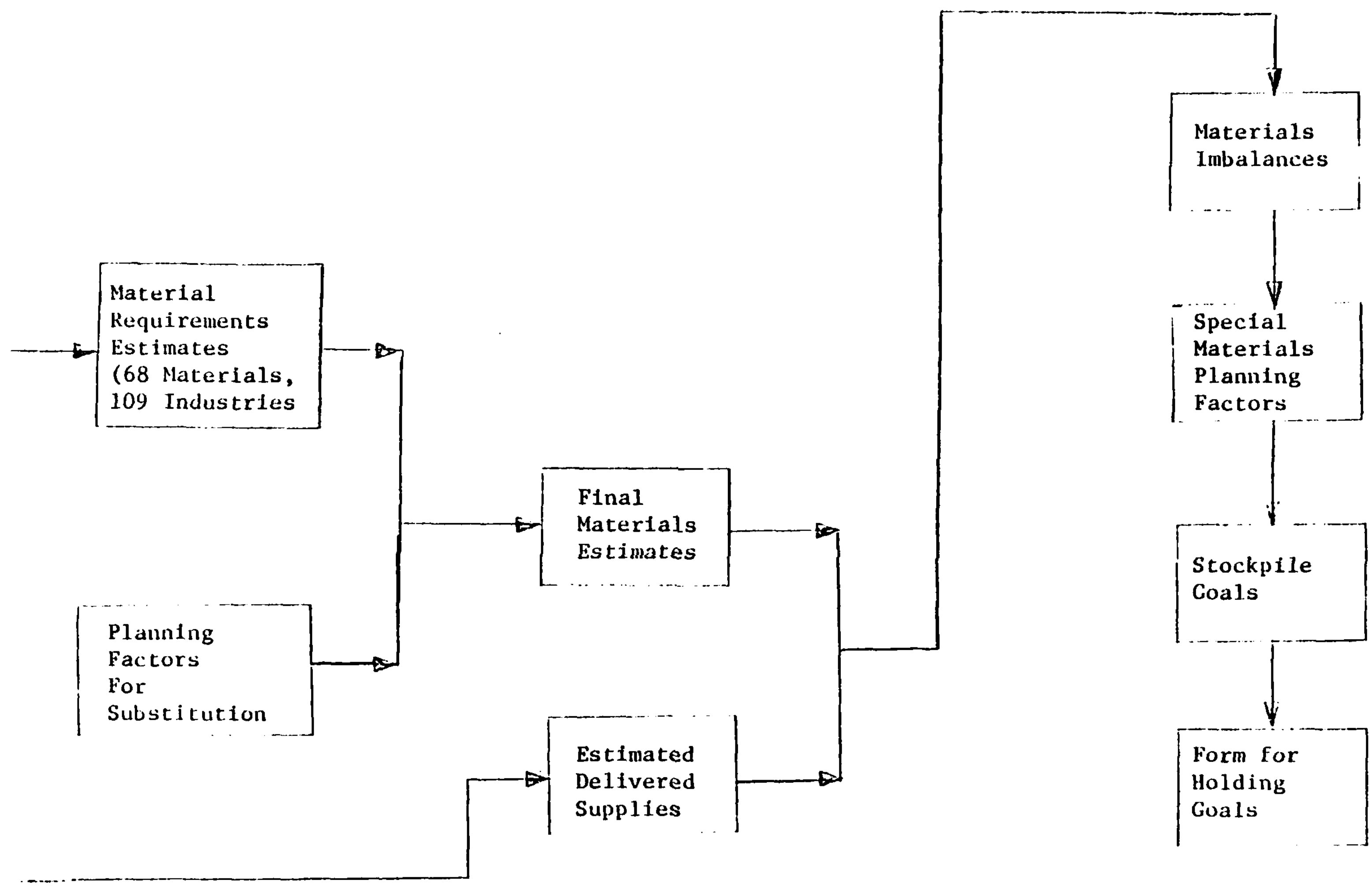


Fig 2a. Stockpile Goal Estimation Methodology
(Once for Each Year, Once for Each Tier)

These inputs reflect civilian austerity, demand shifts, purchasing restrictions, defense expenditure patterns, etc. These factors, plus defense expenditure patterns for both new weapons systems and support costs are introduced, as also are, the allocations to the essential and general civilian categories (21:5).

After these calculations have been made, wartime GNP estimates are made for each sector of the economy. The defense, essential, and general civilian sectors are then spread into 250 categories and run through a Demand Impact Transformation Table which converts the data into demand requirements for 109 industries. These estimates are again processed resulting in the total gross output of each industry necessary to meet the demand of each sector in the economy (21:6).

Estimating Rates of Consumption of Specific Materials.

Department of Commerce industry analysts provide estimates, using a historical data base, on the consumption of 68 stockpiled minerals for the 109 industries. These analysts develop a material consumption ratio (MCR) to project the requirements for the period encompassed by the emergency period. Currently, this is three years. At this point, factors reflecting the willingness to accept shortfalls and to reflect errors in the estimated consumption ratios are introduced. A range of errors are developed. The most conservative errors are applied to the

defense requirements so as to minimize the risk of materials shortages in this sector. The most liberal errors are applied to the general civilian sector (21:7).

Final Material Requirements for Specific Materials.

Total gross output estimates are stated in constant dollars and material consumption ratios in terms of the physical consumption of a material per dollar of industry output. When an MCR for a specific material is multiplied against gross output, that industry's physical consumption for the specific material results. These calculations are performed for each material in the stockpile; for each of the 109 industries; for each tier in the model; and for each year in the model.

Substitution possibilities, ranging from 0-100 percent depending on the material, are considered. At last, consumption estimates can be totaled for each separate industry. These totals become the total requirements for a specific material in a specific tier for a given year (21:8).

Estimating Supplies of Stockpiled Materials.

Supply estimates are generated by considering the production possibilities from over 141 countries. Bureau of Mines mineral specialists track the actual import quantities of materials and provide projections for future availability. Both normal and expanded production capabilities are considered.

Each country, considered as a possible source during times of a possible emergency, is assigned a political reliability factor. The specialists consider, such things as, political orientation toward the United States, ability to maintain material exports in wartime, dependability of the labor force in wartime, and vulnerability to sabotage, when assigning a country a reliability factor. Each country receives a rating indicating the probability of it being able to supply the United States. The countries are then ranked and placed in percentile groups. Countries above the 35th percentile are acceptable sources for supply in the general civilian sector; those above the 70th percentile are acceptable sources for essential civilian sector; and lastly, those countries above the 90th percentile are acceptable to the defense sector (21:10).

Because many of the materials are transported by ship and air, they are vulnerable to interception and destruction by the enemy. For this reason transportation losses are applied to the supplies after political reliability discounts (21:12). From this, an estimate of deliverable supplies is derived. These estimated supplies go through a further series of adjustments (indicated on the flow chart) before becoming the final stockpile goal for a sector. This process is completed for each sector of the economy and for each mineral considered for stockpiling. The final stockpile goal for a mineral is the summation of the three individual sector goals for a specific material for three

succeeding years.

Significant changes in supply, demand, or both of a material could be reflected in the stockpile goal for that material changing from zero or being reduced to nothing.

This model offers several advantages over previous ones because the estimates are internally consistent. For example, chromite consumption is based on steel output, inturn based on the final demand of motor vehicles which inturn is consistent with the overall level and composition of GNP. Another advantage is that it allows for alternate economic scenarios to generate a range of material requirements. Whenever material requirements exceed the estimated supplies, the materials should be stockpiled to cover the identified shortages (14:228).

Form and Quality of Stockpiled Materials.

The materials contained in the National Defense Stockpile are stored in various forms such as ores, alloys, ingots, and powders. The form and quality of materials is important because it impacts on the time and ease with which they can be converted into useful forms.

The National Materials Advisory Board completed a study in 1981 entitled, Considerations in Choice of Form for Materials for the National Stockpile. The report points out that most of the materials in the stockpile were purchased some 30 years ago and made some general conclusions in the following areas:

1. Considerations of Form for Stockpiled Materials.

Major considerations in determining the suitability of a candidate form are materials, processing, and energy.

Materials.

"Material aspects of form selection embrace flexibility, technological currency of the material, and adequacy of characterization [46:132]."

Processing.

The U.S. has limited processing capabilities of certain materials, titanium and aluminium for example. Thus, we are dependent upon foreign nations to process many of the stockpiled materials (46:132).

Energy.

This is another possible constraint on the effectiveness of the stockpiled materials. Aluminium requires large amounts of energy during its conversion process. "It is doubtful that sufficient electrical power could be made available in the vicinity of the existing aluminium smelters to convert the alumina to aluminium in the time frame of a national emergency (46:133)."

2. Stockpiling of Recycled or Recyclable Forms of Materials.

The Board concluded the stockpiling of (46:139) "recyclable forms of materials pose technical problems... that outweigh the possible economic benefits.

3. Need for Rotation of Stockpiled Materials.

They found that technical obsolescence was a major

problem and will impair the utility of the stockpile in times of national emergency. Obsolescence arises from two distinct causes:

> a. Stockpiled material is purchased to the state of the art specifications. As the state of the art improves, specifications are revised and user expectations increase, but the stockpiled material is frozen in time;
>
> b. Stockpile disposals have tended... to emphasize disposal of the purest, most desirable forms, and to leave behind the least pure, least desirable form [46:140].

They recommended that to assure the technological adequacy of the stockpile a formal program of rotation for all stocks as demanded by specification and process changes be implemented (46:140).

4. Specifications of Stockpiled Materials.

The stockpile cannot meet its purpose unless the quality and currency of the specifications for the materials are updated. Failure to do so has led to inventories that are inadequate to meet present and future needs (46:141).

5. Implications for Stockpile Management.

Here, the Board concluded that recent legislation (1979 Stockpiling Act) was beneficial to national security but further benefit would derive from depoliticizing management of the stockpile. It also mentioned, various constraints have prevented the timely buildup of the stockpile and the Presidents annual material plan does not adequately address the qualitative aspects of the stockpile but only the quantitative aspects of its management (46:6-7).

Material processes, technology, energy requirements, specifications, etc., are constantly changing. Thus, the stockpile should be a dynamic entity that reacts to various forces of the market place and technical environment (46:139). If it does not, it can hardly be effective for its intended purpose. Unfortunately, this has not been done in the past and the quality of the materials in the stockpile are suspect.

Quality of Stockpiled Materials.

As previously stated, the majority of stockpiled materials were purchased prior to 1960 and are the results of World War II surpluses. Rightfully then, much concern exists about their quality. Many of the commodities are not useable due to changes in technology, requirements, specifications, etc., and our ability to process some of these materials in sufficient quantities no longer exists. (Much of what the U.S. imports is processed abroad.)

The DOD study entitled, Military Assessment of the National Defense Stockpile concluded:

> The content of the NDS is only marginally adequate to provide significant assistance and support to any surge or industrial mobilization. Therefore, a restructuring of the NDS is needed, and current stockpile goals must be revised [13:1].

The Joint Strategic Stockpile Working Group, who performed the DOD assessment, recommends the addition of gallium, germanium, hafnium, tellurium, and zirconium to the NDS because of their long procurement times.

The National Materials Advisory Board has recently concluded a study to identify materials in the stockpile that require assessment most urgently. Forty-four materials were assessed. Of those, eight were placed in a high priority category requiring immediate further assessment; six were placed in a medium priority category; 12 were placed in a low priority category; and eighteen required no further assessment. Those requiring immediate assessment include chromium metal, chrysotile asbestos, the columbium group, ferrochromium, nickel metal, the tantalum group, titanium sponge, and vanadium pentoxide. Those materials placed in the medium priority assessment category include aluminum oxide, abrasive quality; antimony; flourspar, acid grade, iodine; silicon carbide, crude, manganese dioxide, natural ore, and synthetic material (47:1). Some of the major recommendations of the Board are outlined below:

Initiate action to provide for immediate detailed examination of those materials in the high-priority category and then for those in the medium-priority category.

Keep accurate and complete records on new acquisitions and those materials reassessed in the program initiated (Recommendation 1) and retain test samples for possible future re-evaluation.

Develop and maintain up-to-date specifications on all stockpile materials so as to identify how much of a commodity is available for a specific end use or must be acquired or upgraded to meet goals and to identify which materials can be disposed of if in excess of goals.

To minimize obsolescence and keep the stockpile dynamic, expand the options available to stockpile management to review all holdings biennially for technological currency, to rotate materials on an

appropriate time scale (in general, in terms of years rather than decades), and to report annually all actions or nonactions and the reasons for them. Authorize stockpile management to engage in barter, exchange, and total conversion of materials to current specifications and to different forms that may be required to meet surge in industrial demand in the initial stage of a national emergency.

Structure the stockpile inventories so that forms and purity will be available for direct application to a diversity of critical end uses, cover the demand surge during a national emergency, and will minimize the time needed for upgrading the lower forms to meet end use requirements [47:2-3].

A Department of Commerce study, entitled Critical Material Requirements of the U.S. Aerospace Industry, suggests that all of the low carbon ferrochromium in the National Defense Stockpile is unsuitable for aerospace usage because it contains high levels of carbon and nitrogen. Specialty steel experts say the quality of the chromium may not be of sufficient quality to meet the requirements for aircraft rotating parts (14:141-142).

The same study casts some doubts as to the quality of cobalt in the National Defense Stockpile:

> There is some industry concern about the quality of the current NDS holdings, particularly for aerospace usage. The current stocks were acquired before the extreme high purity superalloys used in today's aircraft engines were developed. In fact, the technical equipment needed to identify the residual content of 15-20 elements critical for current aerospace cobalt usage did not even exist when the current NDS material was stockpiled [14:75].

In addition to questionable qualities of chromium and cobalt, concern should exist over the quality of titanium sponge and the form of manganese. The National Materials

Advisory Board reports that purchase specification data on much of the titanium sponge in the NDS is missing (47:42). This missing data seriously limits the amount of titanium sponge that may be consumed for aerospace usage. Also, the resulting physical quality from deterioration and contamination of some of the titanium makes its use questionable for the fabrication of rotating parts.

Perhaps, the largest concern about manganese is its form in the NDS. It is true the amount of manganese ore in the stockpile is well above its established goal. However, the manganese is mostly in the unuseable basic ore form. The ore must be processed into ferroalloys to be useful. In 1981, the U.S. processing of manganese ore into high, medium, and low carbon ferromanganese was only 23 percent of consumption, down from 83 percent in 1970 (15:109). Thus, it appears the stockpile of ferromanganese is extremely low in face of declining processing capability.

In summary, there are serious problems with the present level of stockpile goals and varying problems involving the quality and form of many materials. The goals are continuously subject to fluctuation and many of the materials in the stockpile are of questionable value to the defense industry.

> Not far in the future awaits sudden recognition of the materials crisis with a possibility of more devastating effects than our current energy crisis. Unfortunately, it will take a major embargo, or fall of South Africa, or Soviet overt threats to interdict our supply routes to wake us up to this materials crisis [44:21].
>
> Jack Schmitt
> U.S. Senator

Strategic Material Dependence and Vulnerability: A Closer Look

Strategic Material Dependence.

This section of the study will examine dependence, vulnerability, and the role of the Soviet Union in what has become known as the resource war.

As stated earlier in this paper, minerals are essential to the health and survival of the United States. They are used in every facet of our "industrial base;" agriculture, transportation, aerospace, manufacturing, electronics, and construction. From an economic standpoint, the value of the materials can be seen by studying figure 3.

The importation of $30 billion worth of processed and raw materials of mineral origins clearly shows our dependence on foreign minerals. This dependence contributed $12 billion toward the United States' trade deficit. The U.S. is second to none in the production and consumption of non fuel minerals.

In 1981, it was estimated that 18,000 pounds of nonfuel minerals per individual in the U.S. were consumed, and this is expected to increase in the future. In fact, the U.S.

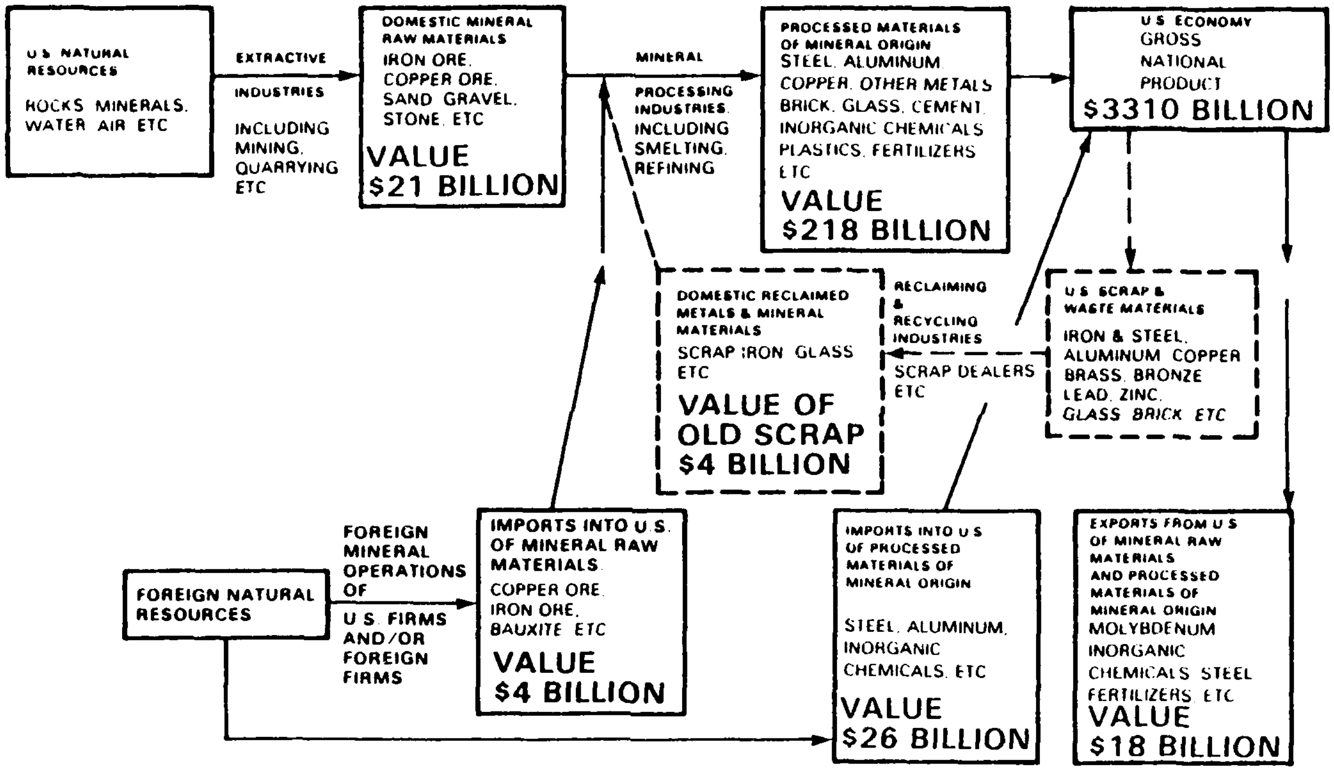


Fig 3. The Role of Nonfuel Minerals In the U.S. Economy
(Estimated Values for 1983) Source: (7:i)

with about 5% of the world's population and 7% of its land area, consumes about 13% of the world's raw materials (6:2). Figures 4 and 5 illustrate per capita consumption and consumption by end use.

Competition for these resources will unquestionably stiffen in the years ahead as we compete with other industrialized nations and the developing Third World Nations, many of whom presently supply the "industrialized world."

As of 1981 (6:3):

> U.S. import dependence on raw materials was about 25% of consumption, and the country was more than 50% reliant on imports for 25 critical minerals. Among the major users only the U.S.S.R. is largely self sufficient. Europe and Japan are 75% and 90% dependent on imports, respectively, and there is mounting evidence that the Soviets are finding it more difficult to meet their own and other eastern block requirements.

Figures 6 and 7 illustrate U.S., U.S.S.R., Japan, and European Economic Community dependence on selected minerals as of the years indicated. Appendix B contains complete listings of U.S. net import reliance of metals and minerals for 1983.

A question of dependence? No, the figures clearly indicate the U.S. is dependent on Canada, Australia, Mexico, the Republic of South Africa, and other developed nations to provide for over two-thirds of our industrial raw materials (6:3). With the exception of titanium, the Soviet Union, Republic of South Africa, and other Southern African nations provide nearly 100% of the materials that are the focus of

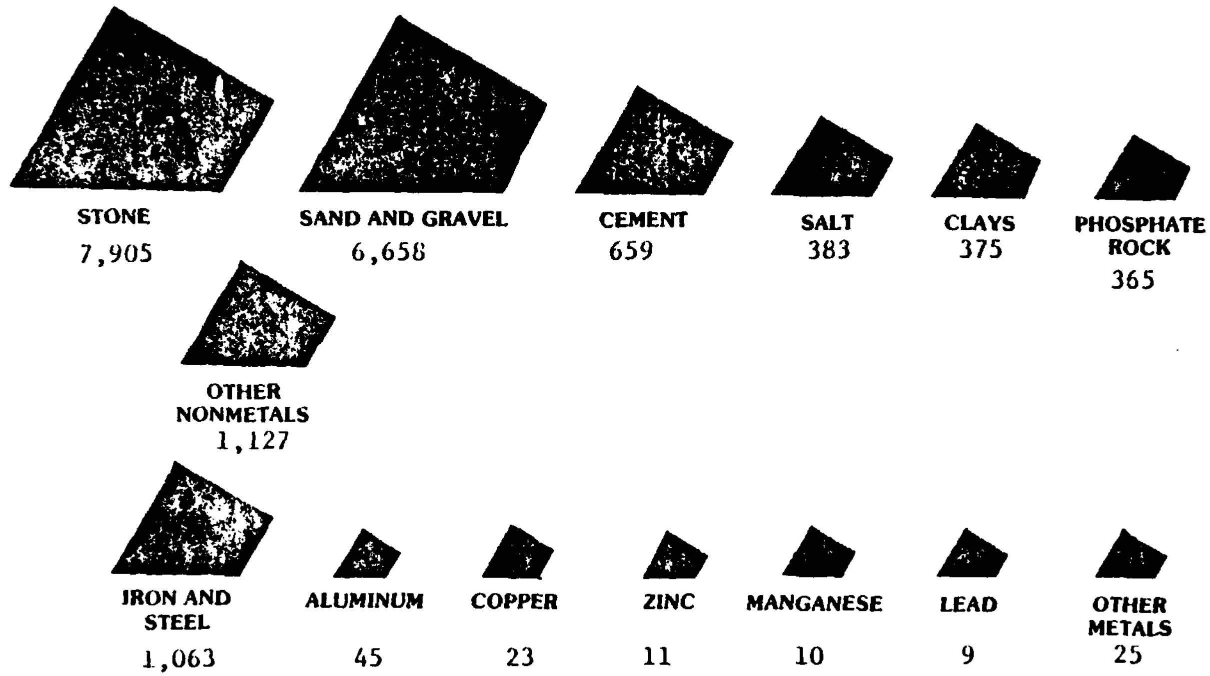


Fig 4. Average Per Capita Consumption In Pounds Source (6:10)

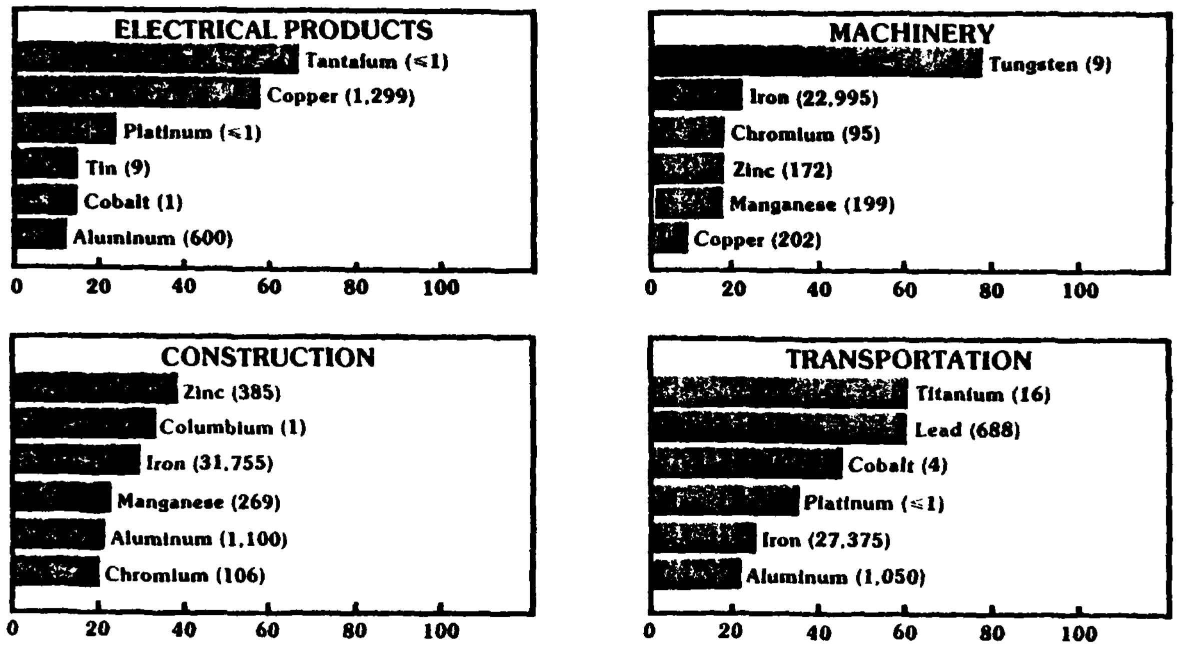
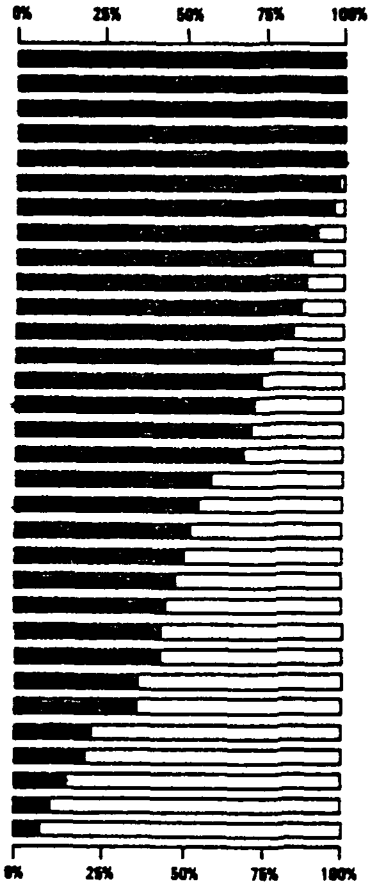


Fig 5. Percentage Of Domestic Mineral Consumption By End Use Source (6:10)



MINERALS AND METALS 2/	NET IMPORT RELIANCE* AS A PERCENT OF APPARENT CONSUMPTION**	MAJOR FOREIGN SOURCES 3/ (1978-1981)
COLUMBIUM	100	BRAZIL, CANADA, THAILAND
DIAMOND (industrial stones)	100	REP. OF SOUTH AFRICA, ZAIRE, BELG.-LUX., U.K.
GRAPHITE (natural)	100	MEXICO, REP. OF KOREA, MADAGASCAR, CHINA
MICA (sheet)	100	INDIA, BRAZIL, MADAGASCAR
STRONTIUM	100	MEXICO
MANGANESE	99	REP. OF SOUTH AFRICA, FRANCE, GABON, BRAZIL
BAUXITE & ALUMINA	97	AUSTRALIA, JAMAICA, GUINEA, SURINAME
COBALT	91	ZAIRE, ZAMBIA, BELG.-LUX., FINLAND
TANTALUM	90	THAILAND, CANADA, MALAYSIA, BRAZIL
CHROMIUM	88	REP. OF SOUTH AFRICA, U.S.S.R., PHILIPPINES, TURKEY
FLUORSPAR	87	MEXICO, REP. OF SOUTH AFRICA, ITALY, SPAIN
PLATINUM—GROUP METALS	85	REP. OF SOUTH AFRICA, U.S.S.R., U.K.
NICKEL	75	CANADA, NORWAY, BOTSWANA, AUSTRALIA
ASBESTOS	74	CANADA, REP. OF SOUTH AFRICA
TIN	72	MALAYSIA, THAILAND, BOLIVIA, INDONESIA
POTASH	71	CANADA, ISRAEL
CADMIUM	69	CANADA, AUSTRALIA, MEXICO, REP. OF KOREA
SILVER	58	CANADA, MEXICO, U.K.
ZINC	53	CANADA, PERU, MEXICO, SPAIN
BARITE	52	CHINA, PERU, CHILE, MOROCCO
SELENIUM	50	CANADA, JAPAN, FED. REP. OF GERMANY, U.K.
TUNGSTEN	48	CANADA, BOLIVIA, CHINA, THAILAND
ANTIMONY	46	REP. OF SOUTH AFRICA, BOLIVIA, CHINA, FRANCE
GOLD	43	CANADA, U.S.S.R., SWITZERLAND
MERCURY	43	SPAIN, JAPAN, ITALY, ALGERIA
GYPSUM	36	CANADA, MEXICO, SPAIN
IRON ORE	38	CANADA, VENEZUELA, BRAZIL, LIBERIA
IRON & STEEL	22	EUROPE, JAPAN, CANADA
SILICON	20	CANADA, NORWAY, BRAZIL, REP. OF SOUTH AFRICA
VANADIUM	14	REP. OF SOUTH AFRICA, CHILE, CANADA
NITROGEN (fixed)	9	U.S.S.R., CANADA, MEXICO, TRINIDAD & TOBAGO
COPPER	7	CHILE, CANADA, PERU, ZAMBIA

*NET IMPORT RELIANCE = IMPORTS - EXPORTS +ADJUSTMENTS FOR GOV'T AND INDUSTRY STOCK CHANGES.

**APPARENT CONSUMPTION = U.S. PRIMARY +SECONDARY PRODUCTION + NET IMPORT RELIANCE

1/ JANUARY 28, 1983

2/ SUBSTANTIAL QUANTITIES OF TITANIUM ORES, RHENIUM, BERYLLIUM AND ZIRCON ARE IMPORTED. DATA WITHHELD TO AVOID DISCLOSING COMPANY PROPRIETARY DATA.

3/ SOURCES SHOWN ARE POINTS OF SHIPMENT TO THE U.S. AND ARE NOT NECESSARILY THE INITIAL SOURCES OF THE MATERIAL.

BUREAU OF MINES, U.S. DEPARTMENT OF THE INTERIOR
(Import-export data from Bureau of the Census)

Fig 6. U.S. Net Import Reliance of Selected Minerals and Metals As a Percent of Consumption in 1982 Source (43:28)

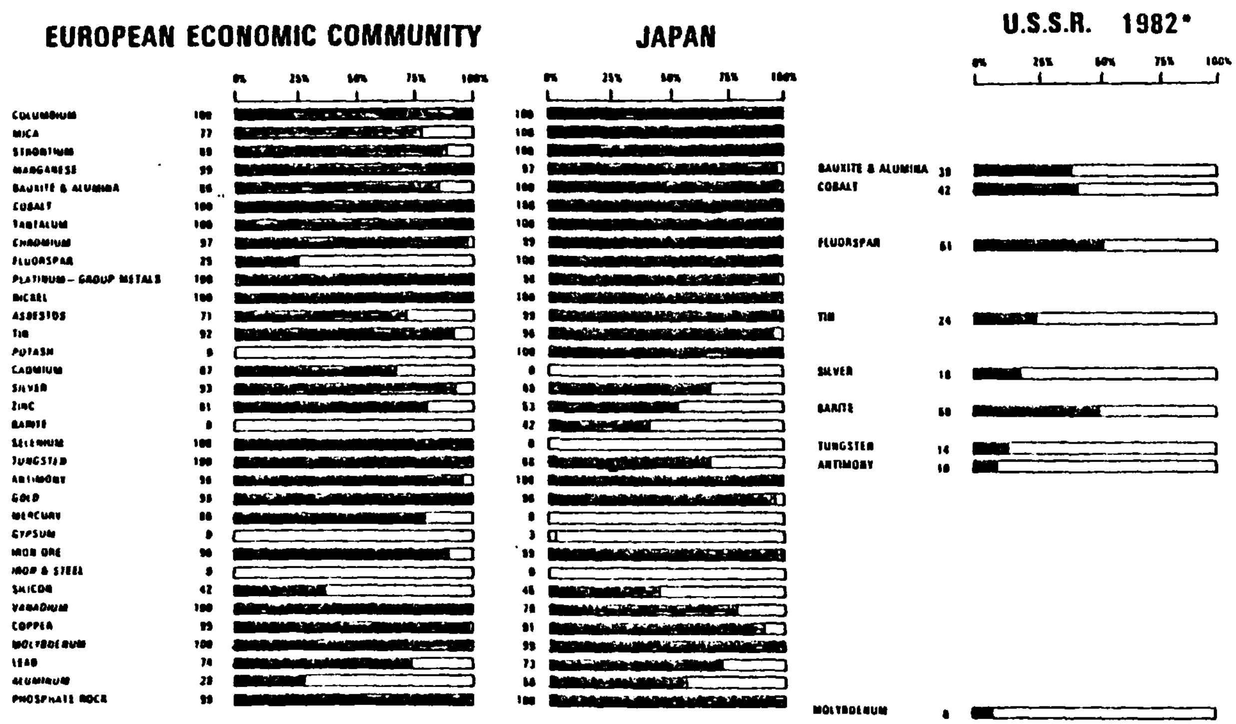


Fig 7. Japan, the European Economic Community, and U.S.S.R. Net Import Reliance of Selected Minerals and Metals As a Percent of Apparent Consumption in 1981 Source (43:29-30)

this study. In fact:

> Much of the world's production and reserves of a number of critical materials are located in two areas of the world: Siberia and Southern Africa. These two areas contain 99% of the world's manganese ore; 97% of the world's vanadium; 96% of the world's chrome; 87% of the world's diamonds; 60% of the world vermiculite; and 50% of the world's flouspar, iron ore, asbestos and uranium. Zaire and Zambia now provide 65% of the world's cobalt [62:25].

With the concentration of these minerals in the U.S.S.R. and politically unstable nations, it becomes not a question of dependence but a question of vulnerability. The following scenario indicates what we as Americans have taken for granted and how much thought the average citizen gives this problem.

> The commuter slipped behind the wheel of his Detroit built sedan. Switching on the ignition system built with Zambian copper and Ghanain aluminum, he drew power from a battery made of Missouri lead and South African antimony to start an engine of Pittsburgh steel strengthened by South African manganese and hardened with chrome from Zimbabwe. The car rolled on tire treads blended from natural rubber from an Algerian photochemical base. The exhaust from Nigerian gasoline was cleansed by Russian platinum. The commuter switched on the radio with invisible traces of cobalt from Zaire and tantalum from Mozambique, heard a newscaster's report of a Communist led coup in a small country in southern Africa. What's that to me, he thought switching to a station carrying the latest sports results [54:1].

Vulnerability: Role of the Soviets.

> Our aim is to gain control of the two great treasure houses on which the West depends: The treasure house of the Persian Gulf and the mineral treasure house of Central and Southern Africa [49:22].
>
> Leonid Brezhnev 1973, President USSR

The Congressional handbook on U.S. Materials Import Dependency and Vulnerability makes a proper distinction between dependence and vulnerability. What criteria may be used to distinguish between a materials import dependency and an import vulnerability? A strategic material is considered vulnerable if there is:

> A sufficiently critical need for the material by the nation's industry such that a prolonged supply interruption would almost inevitably result in catastrophic economic and military consequences; A lack of adequate domestic resources; limited potential for the employment of suitable substitute materials; and lack of adequate alternative sources of supply [12:336].

A study performed for the DOD by the Institute for Defense Analyses identified cobalt, chromium, manganese, and platinum as the four most critical materials because of their insecure supply. Three other materials titanium, tantalum, and germanium were also identified as being essential to defense production but somewhat less vulnerable to supply disruptions (32:I:s14-15).

Table II shows the sources and level of dependence as of 1983 of the four materials in this study. With the exception of titanium, the primary sources of these minerals are located in the USSR and politically unstable regions of Southern Africa.

Having defined vulnerability and examined the sources of the study minerals, we will now review the attitudes and activities of the Soviets towards strategic materials denial.

The Soviet Union has long known the importance of the earth's minerals used in military equipment. Furthermore, figure 8 appeared in Russian textbooks shortly after World War II.

Table II

Materials Import Dependency/Vulnerability

Material	Import Dependence	Primary Sources
Cobalt	96%	Zaire, Zambia, Canada
Chromium	77%	Rep. South Africa (RSA), USSR, Philippines
Manganese	99%	RSA, Gabon, Australia
Titanium (Rutile Ore)	Withheld*	Australia, Sierria-Leone RSA
Titanium Sponge Metal	Withheld*	Japan, China, USSR

Table Compiled From Mineral Commodity Summaries 1984.

*Withheld to avoid disclosing company data. Last published reports in 1979 indicated 100% dependence.

The Soviet strategy regarding strategic metals can be traced to Stalin as early as 1921 when he wrote (54:66-67).

> If Europe and America may be called the front or the arena of major battles between socialism and imperialism, the unequal nations and colonies with the raw materials, fuel, food, and vast stores of manpower, must be regarded as the rear, the reserve of imperialism. To win a war it is not only necessary to triumph at the front, but to also revolutionize the enemy's rear, his reserves.

Many political scientists believe that we are in the midst of a "resource war" with the Soviet Union, and the

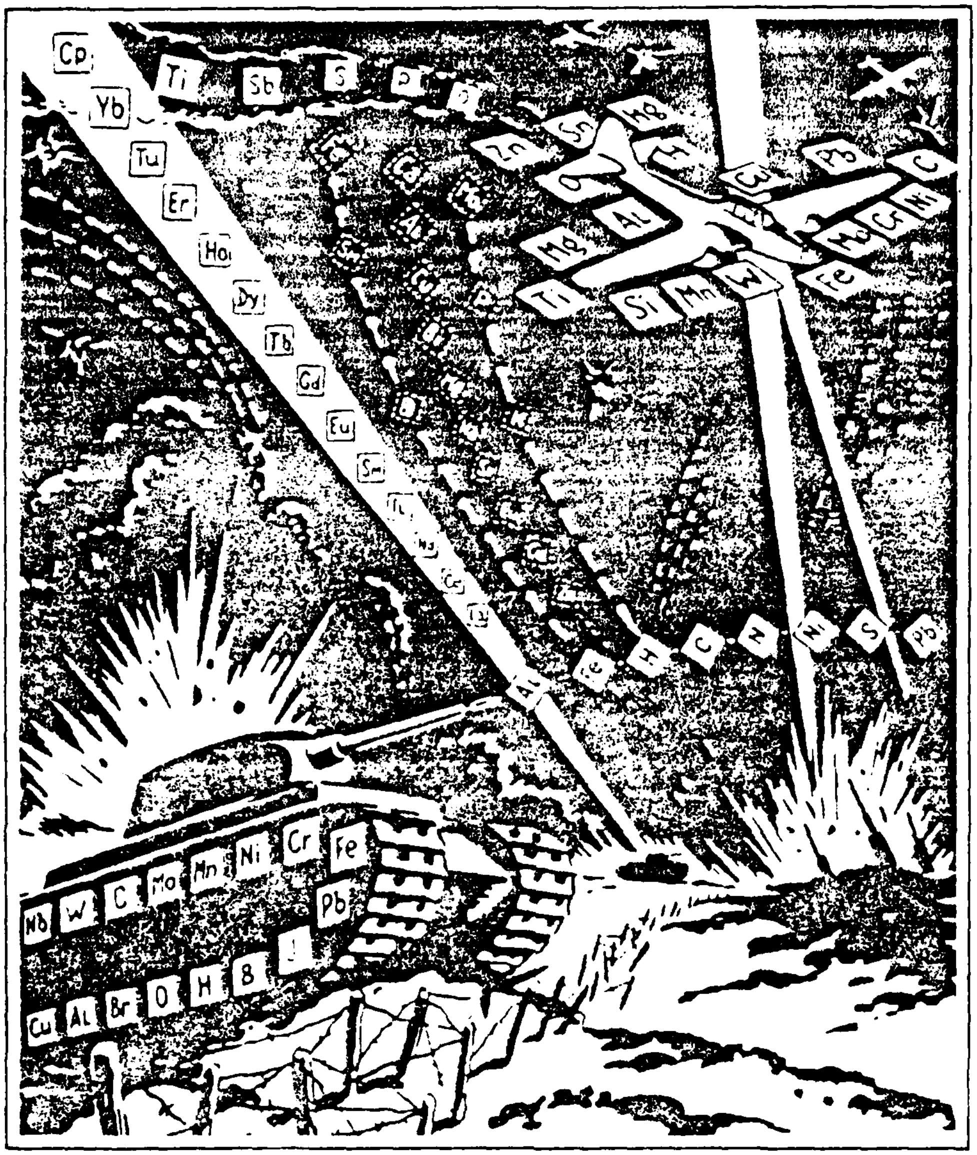


Fig. 8. Soviet Materials Awareness Source (49:6)

Soviets have done an outstanding job of keeping the war just below our threshold of perception. In a speech in 1973, Leonid Brezhnev blatantly spoke of Soviet interest in the Persian Gulf and Southern Africa when he said:

> Our aim is to gain control of the two great treasure houses on which the West depends: The energy treasure house of the Persian Gulf and the mineral treasure house of Central and Southern Africa [49:22].

Examination of figure 9 will clearly show the Soviets' progress toward their goal. Note how the countries with Soviet influence are beginning to encircle the mineral rich nations. Their presence in mineral rich nations is increasing. William Casey cites the examples below as recent [1982] Soviet achievements in the Third World:

> 1. Victory in Vietnam and Hanoi's consolidation of power in all of Indochina.
>
> 2. New radical regimes in Ethiopia, Angola, and Nicaragua.
>
> 3. Possession of Afghanistan, a Russian goal for over a century.
>
> 4. Cuban control of Grenada (and new military facilities there for a further subversion.)
>
> 5. An act of insurgency in El Salvador, where U.S. support of elected government has rekindled old Vietnam memories.
>
> 6. Nicaraguan support of revolutionary violence in Honduras and Guatemala, as well as El Salvador.
>
> 7. U.S. expulsion from Iran, which, though not through any Soviet action, represented a major strategic gain for the U.S.S.R.
>
> 8. Rapid progress toward Cuban control of Suriname, the first breakthrough on the South American Continent.
>
> 9. Pro-Western regimes under siege in Chad and the Sudan [8:28].

James Sinclair, The Strategic Metals War, feels the Soviet minerals denial strategy in Central and Southern Africa is one of physical disruption, domination of

neighboring states, and market manipulation (54:91).

A recent example of physical disruption took place in 1977-1978 when Cuban backed Angolan forces invaded the Shaba

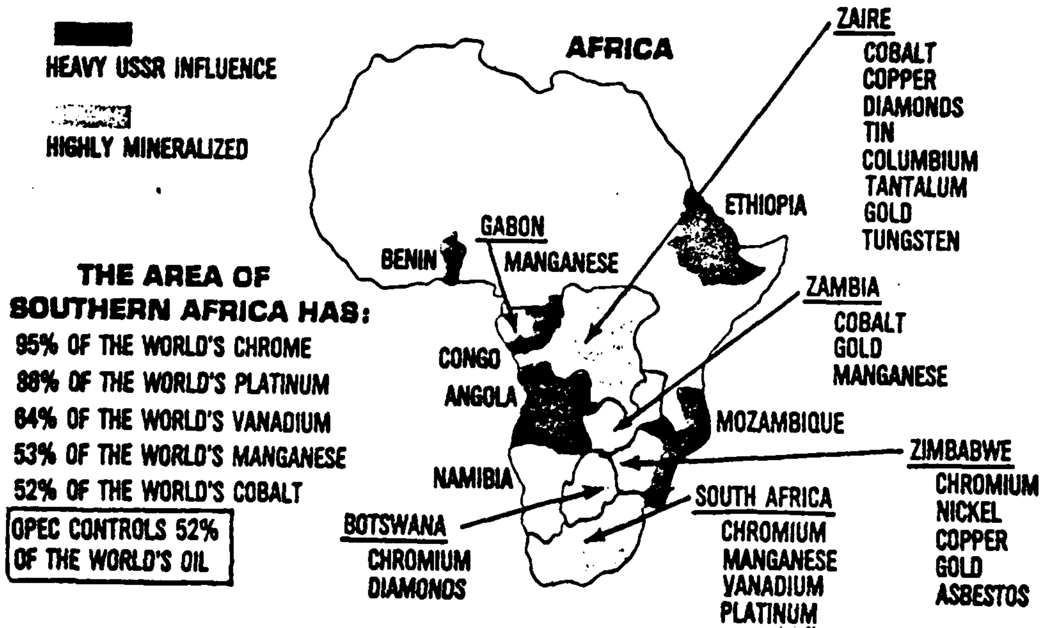


Fig. 9. Africa: Mineral Reserves and Soviet Influence.
Source (49:5)

province of Zaire. Katangan rebels from Angola crossed the border into Zaire attacking the mining industries in this very heavily mineralized area. The raid succeeded in closing the mines and driving out the white engineers who ran the mines (49:95). Survivors of the invasion claimed during interrogation (52:21):

> Their mission was to break up mining equipment, destroy the mining infrastructure, intimidate the western technical personnel and drive them out.

As a result of the invasion, the price of cobalt increased

Katangan rebel invasion of 1978; the second took place in 1979, when a bridge on the Tazara railway to Tanzania was destroyed by Rhodesian factions fueding with Zambia. This reduced Zambia mineral trade with the West by 50 percent. Lastly, in March of 1981 the Republic of South Africa threatened to stop leasing railroad locomotives and cars to Zimbabwe as a result of disputes between these two countries (45:54).

One other possible source of supply interruption would be the interdiction of sea lanes. In view of present international laws, this method is not given consideration except in the case of protracted and direct hostilities between the United States and the Soviet Union. Noteworthy of mention, however, is the amazing progress the Soviet Navy has made in the last decade. We are not dismissing the point as irrelevant, but we feel it is better addressed by strategic planners.

The increasing presence of Soviet proxies and Soviet military personnel in the mineral rich nations of Africa should be of great concern to the United States. Table III provides estimates of the presence of Soviet, Warsaw Pact, and Cuban military advisors in Africa as of 1981.

Through economic and political ties in the region, the Soviet Union has become a major force to be reckoned with. Their goal, no doubt, is to diminish Western influence in the region and hopefully "create a climate in which African states will develop along the Soviet model rather than as a

politically free government oriented towards the market economy (54:75)."

TABLE III

Soviet/Warsaw Pact and Cuban Presence in Africa

Country	Soviet/Warsaw Pact Military	Soviet/Warsaw Pact Civilian	Soviet/Warsaw Pact Total	Cuban Military	Cuban Civilian	Cuban Total
Algeria	600	500	1,100	100	80	180
Angola	1,000	2,000	3,000	20,000	6,500	26,500
Benin	50	10	60	100	20	120
Burundi	10	10	20	20	100	120
Cape Verde	10	20	30	100	10	110
Congo	50	100	150	500	110	610
Ethiopia	1,500	500	2,000	17,000	1,500	18,500
Guinea	110	200	310	200	220	420
G. Bissau	10	50	60	200	60	260
Libya	1,500	1,000	2,500	500	250	750
Madagassgar	20	50	70	40	10	50
Mali	10	20	30	20	10	30
Mozambique	50	100	150	1,000	350	1,350
Sao Tome	30	10	40	100	80	180
Sierra Leone	20	10	30	200	10	210
Tanzania	100	20	120	800	20	820
Zambia	50	10	60	80	10	90
Total	5,120	4,610	9,730	40,960	9,340	50,300

Source (29:44)

According to Sinclair, the Soviets have assigned 20,000 military advisors in the Third World countries where their primary role is in "organizing, training, and penetrating client armed forces (54:91)."

In addition to providing "technical assistance" to many Third World Nations, the Soviets and the Eastern European countries in the Council of Mutual Economic Assistance (COMECON) have entered into 27 different agreements. The basic agreements center on "large-scale Soviet technical aid for the exploration and development of new mines, with the

eventual payment in the form of recovered minerals [40:44]." In addition to these agreements, the Soviets surprised Washington in the spring of 1980 by signing an $85 million arms deal with Zambia.

The arms deal provided for the exchange of Soviet Mig-21's and other weapons for Zambian cobalt. Thus, the Soviets received a substantial supply of a critical material they had been importing in recent years without spending a single ruble (23:59). Their means of procurement, barter, is something the Soviets are old hands at. We should expect to see more of this in the future.

The self sufficiency position of the Soviets has come into question over the past several years as a result of some of their moves in the international metals market. Exports from the Soviet Union of chrome ore has dropped 50% over the past two years. There has also been substantial reduction in the amounts of manganese, asbestos, platinum group metals, nickel, vanadium, lead, and titanium coming out of Russia (40:43-44).

> In the last few months [July 80] the Russians have virtually stopped signing contracts with the West for the future delivery of several critical materials (40:43).

Daniel Fine feels a new pattern is emerging, and it is not a passing phenomenon "that can be explained by temporary shortages of key minerals within the USSR [40:44]." He offers as possible explanations for this historic shift:

> First, similar to other resource producers the Soviet Union recognizes that the value of its own

non-renewable resources will increase in the long term as world energy and mineral supplies become short and thus higher priced.

Second, in the long term the world will need Siberian resources at any price, thus providing the Soviet Union with decisive political power in the affairs of the West.

Third, the outward access allows the Soviet Union to consume and deplete foreign energy and minerals (minimum costs) while preserving a Siberian stockpile-in-the-ground [42:39].

Whatever their reasons, there has been a marked departure from their historical behavior, and this requires close monitoring in the future. For a discussion of Soviet minerals policy and estimates of current and future Soviet mineral production and consumption, see Appendix C (5:7-11).

Soviet Market Manipulation and Embargo.

The Soviet Union is no stranger to manipulating prices in the strategic metals market or completely stopping exports to the United States for political or economic reasons. Our first experience with a Soviet materials embargo resulted from the United States' role in the Berlin Airlift. In 1948, when the USSR was our primary source of chromium and manganese, they halted all shipments to the United States. By the late 1950's when the Soviets formally withdrew their embargo, we were no longer dependent upon them (24:64). By this time, we had diversified our sources.

The Soviets have not only targeted the United States with these type actions but China as well. During the early 1960's, when the Soviets and Chinese developed an

ideological split, they stopped the exports of chromium, cobalt, nickel, and even oil. This action had a devastating impact on the Chinese steel industry and forced China to look elsewhere for these minerals (57:46-47). They too, are involved in Southern Africa.

A good example of <u>price manipulation</u> took place during our self imposed embargo on Rhodesia during the 1970's. As a result of our participation in the U.N. sponsored embargo, U.S. companies were forced to purchase chromium from the Soviets. The Soviets seeing a "capitalistic" opportunity quickly doubled the price. Many experts in the steel industry felt the Soviets were buying Rhodesian chrome and reselling it at inflated prices. As evidence, the buyers pointed to the higher quality of Rhodesian chromium ore (57:46).

Another case involves titanium. During the late 1970's when the Soviets were the primary supplier of titanium sponge, they suddenly withdrew from the market. This withdrawal, along with increased demand for titanium by aerospace users, resulted in large increases in lead times for the material and an eight fold price increase (52:21). Today, there are three major producers of titanium sponge in the U.S., and as long as there is a supply of raw materials, these companies can produce the quantities required (39:57).

A more recent example of direct interference in the market was during the 1978 raids into Zaire. It has been estimated that the Soviet Union bought 300 tons of cobalt in

the months prior to the invasion by Katangan rebels. These purchases were made in small quantities of 30 to 50 tons so perhaps not to draw attention (42:46). As a result of the raids, the price of cobalt increased from six dollars to fifty dollars a pound on the spot markets.

In 1981 there were five separate reports that Soviet representatives offered to sell 4,000 tons of nickel at $2.37 per pound in North America. The prevailing market price was $2.87. Was this an attempt to drive two Canadian firms suffering from weak markets and poor sales out of business? If successful, it would certainly make us dependent upon the Soviets for future supplies of nickel (54:69).

A more recent example is pointed out by Daniel Fine, which suggests, as in the nickel example the Soviets probable intention of damaging the U.S. Mining Industry:

> The Soviet Union which has recently entered Canada with lithium sales 30 percent below the U.S. producer prices. Although there are many explanations for this, such price cutting creates difficulties for U.S. producers to maintain their share of the Canadian market. It affects the return on investment of those producers and, of course, the profit sheets for the year and capital expenditures for expansion for lithium production capacity in the future. So there is whole complex set of transactions, which under resource war or conflict, differs from the military concept of disruption and denial [44:30-31].

<u>Conclusion</u>

The Soviet Union's menacing presence is ever increasing throughout the Third World. Through economic initiatives

and alliances, political interference and maneuvering, and blatant aggression, they are quickly nearing a position from which they will be able to implement their strategy of resource denial against the United States and its allies. Resource denial is only a part of their larger scheme of world domination. They have been successful around the world in such areas as Africa, South America, the Caribbean, and Southeast Asia.

James Miller, writing from a Soviet leader's perspective, in his article, "The Strategic Mineral Vulnerability of the West: A Soviet Perspective," writes

> Under Marxism Leninism, our strategy for world domination is truly global. Fortunately for us, most American and other Western politicians and legislators continue to think on an issue-by-issue basis. Thus, they do not see the availability of strategic and critical materials as a central ingredient in the capitalist world's very ability to survive. They do not recognize the broad geopolitical implications of individual world events to the extent that they think of international affairs at all...[41:20].

To a large extent, we believe this is true. The Congress of the United States does a lot of talking but takes little significant action and probably will not until the U.S. experiences another major interruption of minerals. It took the oil embargo of the 70's and cobalt interruptions of the late 70's to awake this country to the fact of dependence upon many materials essential to our survival.

Miller goes on to write (41:20):

> The capitalistic world is ill prepared to respond directly to Soviet uses of force in Southern Africa. There is no meaningful military or naval

> presence...Even the USA's so called rapid deployment force...would not likely be used in Southern Africa...our sources in Washington report that there are no significant contingency plans for American military forces to intervene in Southern Africa...The greatest needs of the capitalistic nations has been to develop a cohesive strategy for dealing with Southern Africa in a sound manner. But fortunately for us, this has not been forthcoming.

The Soviet Union is spending vast amounts of resources in the developing world to promote national liberation and gain effective control over the energy and nonfuel mineral resources. These mineral resources represent the weak link of the Western World, and when it breaks, the capitalists will crumble for want of vital raw materials.

"The resources disruption/denial and national liberation components of our global strategy work hand in hand toward the final victory of socialism over capitalism [41:21]."

Selected Minerals Profiles

In order to possess a viable industrial base, the United States must have the necessary strategic materials and minerals to sustain its economy during a time of national emergency. According to Dr. John Morgan, Chief Staff Officer of the U.S. Bureau of Mines:

> At a time [1983] when the distinctions between war and peace are blurred and when competing political and economic philosophies are characterized by varying degrees of economic warfare and cold war, a viable industrial base is a strategic necessity [43:16-20].

We believe the following four materials will be essential to the defense industrial base because of their

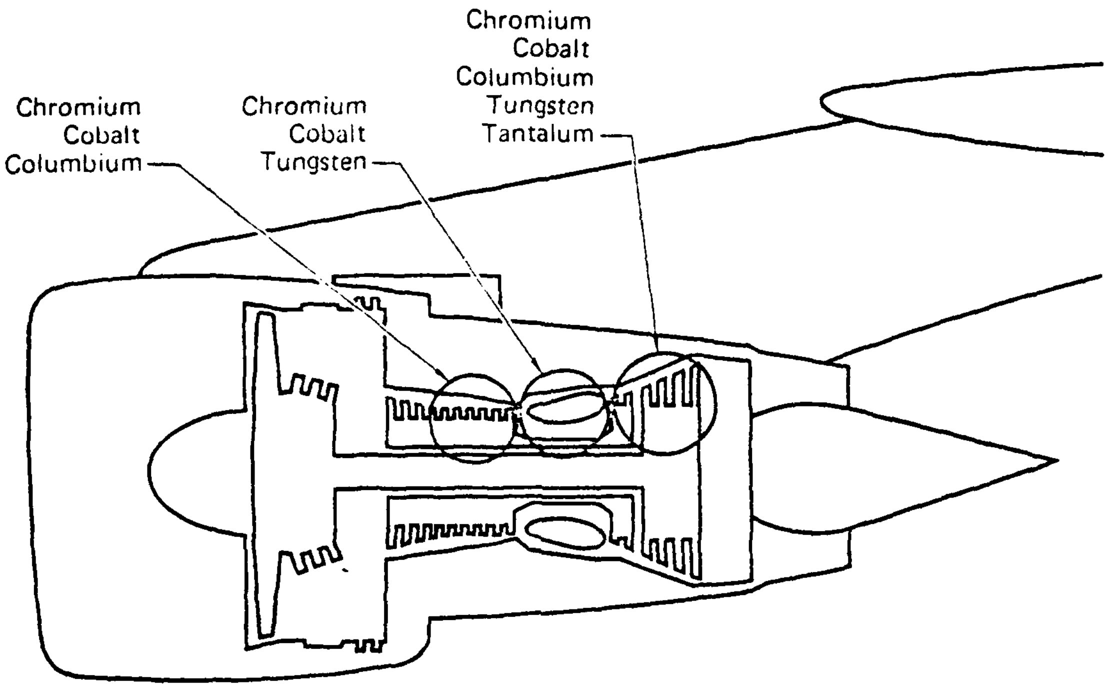
demand and uses: chromium, cobalt, manganese, and titanium. An example of the important demand for these strategic materials is the Pratt and Whitney F-100 Turbofan engine which is used in the F-15 and F-16 aircraft. The manufacture of one engine requires: 5,366 pounds of titanium; 5,204 pounds of nickel; 1,656 pounds of chromium; 910 pounds of cobalt; 720 pounds of aluminum, 171 pounds of columbium; and 3 pounds of tantalum. Figure 10 illustrates where these materials are used in the engine and the extent of U.S. dependence on other countries for them. The net requirements are somewhat less since some of the materials can be recovered through the recycling of scrap (12:31).

Each of the four strategic materials mentioned previously will now be profiled separately.

Chromium.

Chromium is one of the United States' most important strategic and critical materials because it is vital to the production of iron, steel, stainless steel, and nonferrous alloys. Chromium is used in these products to enhance their hardness and resistance to corrosion (50:1). Because of these important properties, about 70 percent of the world's chromite is used in metallurgy where it is processed into ferrochromium, an intermediate product used in the production of stainless and heat resistant steels (14:105).

Chromium is very important to the United States aerospace industry where it plays a critical role in the



Metal (lb)	U.S. dependence on foreign supplies, 1979 (%)
Titanium (5366)	100 (primary raw material)
Nickel (5204)	77
Chromium (1656)	90
Cobalt (910)	90
Aluminum (720)	10
Columbium (171)	100
Tantalum (3)	96

Fig 10. Strategic Materials in an F-100 Turbofan Engine
Source (38:6)

production of jet engines and also tools used in aircraft production. Although chromium, used by the aerospace industry, makes up only a small portion of the final product, it adds vital performance characteristics (14:96). Aerospace usage of chromium is in the neighborhood of less than six percent of total U.S. chromium consumption; however, 90 percent of chromium applications in the alloy materials used by the aerospace industry are irreplaceable at present technology levels (14:96).

According to estimates made by the Department of Defense, U.S. industries consumed 35.1 short tons of chromium for defense production in 1979, out of a total 515.87 short tons used by U.S. industries. Table IV indicates the defense industries which require chromium for their final product and the amount consumed.

There are no known reserves of chromium in the United States, thus, making the U.S. import-dependent on this material. The United States Bureau of Mines statistics show that the U.S. is 91 percent import-dependent for chromium; the remaining nine percent is recycled from scrap (2:32). It is also noteworthy to mention that jet engine and rocket engine manufacturing needs for chromium cannot be satisfied from commercial scrap because of purity requirements. Therefore, the United States is 100 percent dependent on foreign sources for chromium when it comes to defense uses (2:32).

Table IV

Leading Chromium-Using Industries for Defense Output

Industry	Amount Consumed For Defense (Short Tons)
Aircraft Engines & Engine Parts	5.46
Aircraft Parts & Equipment	3.67
Complete Guided Missiles	3.29
Nonferrous Rolling & Drawing	3.10
Radio & TV Communications Equipment	1.85
Shipbuilding & Repairing	1.63
Ammunition	1.62
Electronic Components	1.21
Blast Furnaces & Steel Mill Products	1.14
Iron & Steel Forgings	1.08
Metal Stampings	0.81
Fabricated Platework	0.71
Fasteners & Screw Machine Products	0.71
Tanks & Tank Components	0.70
Steam Engines & Turbines	0.49
Other Industries	7.63
Total:	35.12

Source:(11:29)

The most important fact about the world's chromite supply is that, together, Russia, Zimbabwe, and the Republic of South Africa control more than 80 percent of the world chromium production (2:33). In addition, over 99 percent of the world's identified resources of chromite are in two southern African countries, South Africa and Zimbabwe (25:289).

Chromium must be given strategic consideration since in almost every national emergency since World War I, the domestic chromium supply has been of national concern. Domestic resources of chromite are low grade and would be

able to supply only a small portion of the nation's domestic requirements (4:175). During the 1950's and 1960's, Government stockpiles of chromium material (primarily chromite) were created to alleviate possible supply interruptions from unstable countries where chromite is imported from (4:176); however, the stockpile goals have not been met to ensure a three year supply of chromium for U.S. industries in the event of an emergency or supply disruption. The stockpile is currently 39 percent deficient in total chromium related material (4:176).

It must be noted that chromium is commercially traded as chromite and ferrochromium; however, due to a process of vertical integration, chromite producing countries have recently been developing ferrochromium production capacities. For example, in 1971, the U.S. obtained 87 percent of its chromium imports in the form of chromite and 12 percent in the form of ferrochromium, whereas, in 1981, the amounts imported were about 50 percent from chromite and 50 percent from chromium ferroalloys (50:4).

In 1982, the largest U.S. high carbon ferrochromium manufacturer entered Chapter 11 of U.S. Bankruptcy Code. A further investigation showed domestic high-carbon ferrochromium manufacturers were operating at 50 percent capacity, because they could not compete with foreign countries that produce high-carbon ferrochromium at a much lower cost. This is significant since chromite must first be converted to ferrochromium if it is to be used in steel

production. Presently, U.S. industries have the capacity to produce only 50 percent of the ferrochromium that is consumed annually in the United States. Until November 1982, domestic high-carbon ferrochromium producers were protected from foreign competition under the Trade Act of 1974; however, that protection was not extended and expired in 1982 (50:4). This action will probably result in more ferrochromium producers leaving the industry.

In conclusion, the estimated U.S. apparent consumption of chromium in 1983 was 340,000 tons, and the domestic mine production was zero. Using a 1981 base, the demand for chromium is expected to increase at an annual rate of 2.2 percent through the year 1990 (7:33). Unfortunately, as our demand for chromium increases, so does our dependence on foreign sources for chromium material. In addition, an even more startling fact is that 78% of U.S. chromium is imported from the three Governments of South Africa, Russia, and the Philippines who could easily lose favor with the U.S. and cut its supply of chromium at any time (7:32).

<u>Cobalt</u>.

Cobalt is considered a strategic and critical material because of its essential defense-related uses and the high degree to which the U.S. depends upon imports for its supply. There are no known domestic cobalt reserves, and more than 90% of the U.S. consumption is imported while the remaining 10% comes from raw scrap. [*Note: Mineral

reserves are that part of the U.S. reserve base that could be economically extracted or produced (35:4).] In view of these facts, an important strategic concern for the United States is the development of policies to prevent cobalt supply disruptions. The necessity for such policies was illustrated by events which took place in Zaire, our major supplier of cobalt, in the late 1970's (35:1).

First, Zaire suffered major transportation problems and, later, underwent two short-lived invasions by a rebel army in the cobalt-producing province of Shaba in 1977 and 1978. These invasions resulted in the temporary and brief closing of cobalt mines in Shaba, and as a result, Zaire reduced allocations of cobalt to its worldwide clients by 30%. Prior to this, the U.S. had been selling cobalt from its national stockpile. Between the years of 1967 and 1976, the United States sold about 60 million excess pounds of cobalt, but in 1976 U.S. stockpile sales were stopped. Shortly after that, the price of cobalt soared upward; the price rose from $5.20/pound in January of 1977 to $25/pound in February of 1979 (35:1).

A number of policies have been suggested which would prevent cobalt disruptions. They are as follows (35:1):

1) The acquisition of cobalt for the national stockpile.
2) Subsidies which would encourage the domestic production of cobalt.
3) *An industrial or economic* stockpile.
4) The increase of federal funding for the research and

development of substitutes for cobalt.

5) Expanded access to public lands for the locating of domestic cobalt mines.

6) The accelerated development of ocean mining to obtain cobalt.

Next, let's consider why cobalt is so important to the United States. Cobalt is primarily used in military hardware as a superalloy for jet engines, alnico and cobalt-samarium permanent magnets, stellate linings in gun barrels, and cobalt-pigmented paints. In addition, cobalt is used to make cutting tools and drilling and mining equipment (35:1). Usage categories along with their perspective percentages are: industrial and aircraft gas turbine engines (37%), magnetic materials for electrical applications (16%), driers (11%), catalysts (10%), metal cutting and mining tool bits (7%), and other uses (19%) (7:36-37).

The properties of cobalt making it so useful include its ability to impart strength, heat, and corrosion resistance to superalloys (35:1). In addition, cobalt is one of the strongest magnetic elements known and has the highest Curie point, which is the temperature above which a material loses its ferromagnetic properties (35:2). Cobalt often constitutes only a small portion of the final weight of a product but it adds vital characteristics which are essential to performance; for example, cobalt constitutes only 6% of the weight of the F-100 engines used in the F-15 and F-16 but cobalt is critical in meeting the engine's high

performance requirements (14:63).

Table V summarizes the leading cobalt-using industries for defense output; they accounted for 90 percent of total cobalt consumption for defense production in 1979.

Table V

Leading Cobalt-Using Industries for Defense Output

Industry	Amount Consumed For Defense (Thousands of Pounds)
Aircraft Engines & Engine Parts	1,712.0
Radio & TV Communications	497.8
Electronic Components	241.8
Plating and Polishing	117.2
Special Dies and Tools	100.2
Other Industries	301.1
	Total:2,669.0

Source:(11:35)

What are the problems facing the U.S. concerning cobalt? The basic problem the U.S. has concerning cobalt is its dependence on overseas sources (35:3). It is predicted that the United States will continue to rely on Zaire as its major supplier of cobalt at least until the year 2000 (35:2). Another problem is that higher grade deposits are concentrated in only a few areas of the world (Zaire, Zambia, Botswana, and the Republic of South Africa). Further complicating matters is the fact that the majority of cobalt is a byproduct of other metals, such as copper or nickel, and as a result, the production of cobalt is

dependent upon the rate of mining for these metals. Many potential cobalt producers are unwilling to compete with Zaire since it can produce the metal at a lower cost. In addition, most of the cobalt in the National Stockpile is <u>not of sufficient quality</u> for major strategic applications since most of it was purchased prior to 1960 when minimum specifications were lower. Finally, for most end-uses there are <u>no effective substitutes</u>, and nearly all the metals which can be used as substitutes are strategic metals themselves (35:3).

Next, let's consider the economic factors surrounding cobalt. One of the major relationships in the cobalt market is the byproduct relationship between cobalt and nickel or copper and the resulting relative price inelasticity of supply under normal market conditions. Since cobalt is a byproduct of copper and nickel, over the long term, the price of cobalt is likely to be two or three times the price of nickel and seven or eight times the price of copper. The price level is critical since an increase in the price of cobalt could result in a reduced demand in nonstrategic areas where demand is more responsive to fluctuations in price. In addition, significantly higher prices would increase research for effective substitutes (35:10).

Table VI indicates changes in the price of cobalt from 1960-1982. Some events which have affected the price of cobalt include (35:11):

TABLE VI

Time Price Relationships For Cobalt

	Average Annual Producer Price, Dollars Per Pound	
Year	Actual Prices	Based On 1981 Constant Dollars
1960	1.54	4.34
1961	1.50	4.18
1962	1.50	4.12
1963	1.50	4.06
1964	1.50	3.99
1965	1.62	4.22
1966	1.65	4.16
1967	1.85	4.53
1968	1.85	4.34
1969	1.89	4.22
1970	2.20	4.66
1971	2.20	4.44
1972	2.45	4.75
1973	3.00	5.50
1974	3.46	5.83
1975	3.98	6.14
1976	4.44	6.51
1977	5.58	7.73
1978	11.53	14.89
1979	24.58	29.25
1980	25.00	27.31
1981	19.73	19.73
1982	12.89	12.17

Source:(35:10)

1) The removal of cobalt in 1964 from the list of commodities prohibited from being shipped to Sino-Soviet countries.

2) A 39% increase in the industrial consumption of cobalt in the U.S. from 1965-1969 due to the Vietnam War.

3) The nationalization of mines in Zaire in 1967.

4) Increased demand for nickel because of the Canadian nickel strike in 1969.

5) The currency realignment between the United States and Belgium between 1972 and 1978.

6) The halt in sales of U.S. cobalt from the national stockpile in 1976.

7) The armed invasion of the Shaba province in 1978.

8) Reduced copper and nickel production and poor extraction efficiency along with an unusually high demand for cobalt.

Although no domestic cobalt was produced in 1981 (35:13), the increasing price and industrial demand for cobalt within the next few years could make the domestic mining of cobalt more profitable again. For example, the expected U.S. production in the year 1990 will be 6 million pounds; this includes an estimated 3 million pounds from the Blackbird sulfide district in Idaho, 2 million pounds from the lead belt of southeastern Missouri, and 1 million pounds from the Duluth Gabbro in Minnesota (4:213).

The demand for cobalt is expected to increase in the future due to energy shortages and the resulting increase in the rate of oil and gas drilling and coal mining in which cobalt is used extensively to manufacture drilling and mining equipment. More stringent environmental standards will also increase the demand for cobalt catalysts used to remove sulfur from light petroleum distillates used in gasoline (35:13).

Finally, the U.S. apparent consumption of cobalt in 1983 was estimated to be about 5500 tons, and based on a 1981

base, the demand for cobalt will increase at an annual rate of 2.0 percent through 1990 (7:36-37).

Manganese.

Manganese, used in the production of all steels and cast irons, is considered to be the most important addition in the steelmaking process. It is used in molten steel to counteract the adverse effects of sulfur and prevent the brittleness that would otherwise develop in steels containing sulfur. Additionally, manganese imparts increased strength, toughness, and hardness to steel and iron (15:77). Manganese is added to the steelmaking process as an alloy, the most common form being high carbon ferromanganese, for which there is no established goal in the stockpile and limited domestic production capacity.

It is estimated that the world reserves of manganese ore are about 1.5 billion tons. Russia and South Africa are credited with 1.2 billion tons with the remainder distributed among Australia, Gabon, and Brazil (4:553). In addition, the U.S. Bureau of Mines identifies world resources other than reserves at 1.6 billion tons of contained manganese which is not economically feasible to extract at this time (4:553).

The U.S. currently has no reserves of manganese ore containing 35 percent or more manganese. [*Note: In order for ore to qualify as manganese ore it must contain at least 35 percent manganese.] The manganese deposits in the U.S.

are low grade and would require extensive and expensive processing to extract the high quality manganese required by industry (4:553). Furthermore, in 1976 a panel from the National Materials Advisory Board of the National Research Council concluded that the domestic land based resources of manganiferous materials [lower grade ore containing less than 35 percent manganese but not less than five percent] "should not be developed except in a dire emergency [4:553]." In addition, a Minerals Availability System (MAS) report indicated in a study of representative domestic deposits that profitable utilization of these low grade ore deposits would require an ore price ranging from five times to nearly 20 times the current price level (33:7).

The U.S. Bureau of Mines estimates that in the event of a materials emergency, a lead time of at least three years or more would be required to build plants large enough to refine the low grade ore in the United States to meet industry demands (4:553).

In 1980, the United States imported 98 percent of its manganese ore and 73 percent of its ferromanganese (a processed form of manganese). The U.S. had the following import sources of manganese and ferromanganese by percentage of total imports: Manganese ore: South Africa 25.8 percent, Gabon 23.8 percent, Brazil 10 percent, Australia 31.6 percent, and Mexico 6.7 percent. Ferromanganese: South Africa 37 percent, and France 36 percent (11:42).

It is important to note that in the last three years,

statistics indicate that the United States is becoming more dependent on South Africa for its manganese ore. Presently, the U.S. is importing approximately 40 percent of its manganese ore requirements from South Africa. Similar statistics outline the ferromanganese trade. The U.S. now imports 35 to 44 percent of its ferromanganese from South Africa, whereas, in 1977 the U.S. only imported 30 percent of its ferromanganese from South Africa (65:10). Several analysts suggest that by 1990 South Africa will be our primary supplier of manganese ore and ferromanganese (65:10). In addition, South Africa has the potential of encountering severe political unrest in the next few years, and the U.S. supply of manganese ore and ferromanganese could be vulnerable to a supply disruption.

A major concern to strategic planners is the decline of the domestic ferroalloy industry because ferromanganese can be imported at a much lower cost than it can be produced in the U.S. This resulted in many ferroalloy manufacturers leaving the industry (33:2). The United States is now well below self-sufficiency in capacity for producing manganese ferroalloys (33:2). Table VII shows the domestic production of ferromanganese as a percentage of consumption since 1970 and demonstrates the increasing U.S. dependence on foreign manufacturers for ferromanganese.

In December 1982, President Reagan announced a decision that will allow a portion of our stockpiled manganese ore to be converted to ferromanganese in order to keep more U.S.

Table VII

U.S. Production and Consumption of Ferromanganese
(000 short tons, gross weight)

Year	Consumption	Production	Percent
1970	1001	835	83
1971	899	760	85
1972	968	801	83
1973	1117	683	61
1974	1116	544	49
1975	882	576	65
1976	897	483	54
1977	886	334	38
1978	986	273	28
1979	976	317	32
1980	789	189	24
1981	821	193	24

Source: (15:92)

ferroalloy furnace and processing plants in business. The plan calls for production of about 577,000 tons of ferromanganese over a 10 year period (33:5), thus, keeping the ferroalloy industry from declining further.

To assure the U.S. continues to have a supply of manganese, the Council of National Defense designated metallurgical-grade manganese ore as a strategic mineral in 1916. However, World War II was the impetus that started the stockpiling of manganese ores and ferroalloys from a combination of acquisition programs that included purchases of a variety of foreign ores and barter programs for surplus U.S. agricultural products. The accumulation of manganese materials in the stockpile peaked in the mid 1960's at about 5.6 million tons of contained manganese (33:4). Then, in

1965, the General Services Administration began selling excess manganese from the national stockpile in order to satisfy the steel industry's demand for manganese. However, as a result the manganese inventory had dropped to 2.1 million tons of contained manganese in 1982, of which three-fourths is ore and the balance is ferroalloys.

It appears that the U.S. demand for manganese will continue to increase through the year 2000 as the demand for steel increases by an annual growth rate of 1.4 percent. This equates to a U.S. demand for manganese of between 1.79 and 2.38 million short tons annually.

A major problem that confronts the United States Government is the lack of domestic manganese reserves and the lack of significant production rates of manganese. Extreme concern exists over the absence of domestic supplies of manganese and the possibility of a supply disruption due to war or political problems in countries from which the U.S. imports manganese (33:5). The U.S. could produce a large quantity of manganese items; however, the cost to the private sector is prohibitive at this time. In contrast to the United States' situation, the Soviet Union is self sufficient in manganese items as a matter of national policy and is also the world's leading producer of manganese (33:5).

As a final note, there is currently no substitute for manganese in the steelmaking industry, and if the supply were disrupted for a long period of time, U.S. industries

would have to rely on the national defense stockpile for manganese for essential items until a domestic supply could be started. Presently, the National Defense Stockpile has an adequate supply of manganese ore to meet a three year emergency, however, little capacity to produce ferromanganese which is the form the steel industry needs it in. In addition, the lead time for producing usable manganese from our domestic supplies of low grade manganiferous ore would be three or more years.

Titanium.

Titanium is one of the most abundant elements, making up about 0.6 percent of the earth's crust (37:1). It can be found in two mineral sources: rutile, containing 96 percent titanium dioxide and ilmenite, containing 52.7 percent titanium dioxide. Rutile is not as common as ilmenite and is the only titanium mineral listed as critical and strategic and is, therefore, stored in the National Defense Stockpile (12:120).

To arrive at its end use form, titanium undergoes a two-step refinement process. First, the raw minerals, rutile and ilmenite, are processed into titanium sponge (a porous metal which is not useful in this form), and secondly, the titanium sponge is put through a melting process which yields titanium metal (2:19). It is this metal that is extremely important to the U.S. aerospace industry because of its high strength-to-weight ratio and its resistance to

heat and corrosion. Because of these unique properties, titanium alloys are used in the airframes and engines of high performance military and civilian aircraft (37:2).

The aerospace industry accounts for about seventy percent of the usage of titanium metal and is, therefore, the major user of titanium metal. Within the industry, titanium metal is used to build aircraft, turbine engines, guided missile assemblies, and spacecraft. The other 30 percent is used mainly in the chemical and electrochemical processing industry, power plants, and the steel industry (14:143). The aerospace industry currently has no substitutes for titanium which possesses the high strength-to-weight ratio required in high performance aircraft.

The U.S. currently mines about one-third of its titanium raw material requirements with the remaining two-thirds being imported mainly from Australia, in the form of rutile and ilmenite, and also Canada, in the form of titanium slag. Due primarily to economic reasons, U.S. producers of titanium metal have relied on imported natural rutile from Australia, but our dependence on imported rutile could be eliminated by making synthetic rutile from domestic ilmenite although at a somewhat higher price (37:1).

Another major problem affecting the titanium metal industry is the large fluctuations in demand for titanium caused by the cyclical nature of the aerospace industry. Producers of titanium sponge have repeatedly increased capacity in response to anticipated demand and in the end

have been left with excess capacity when programs are canceled or cut back. The United States Government could help stabilize demand by better long-range planning and forecasting of aerospace industry requirements and increased use of multiyear procurement contracts (37:2).

During recent years, an additional problem has surfaced which concerns Air Force planners--that is the insufficient forging capacity to meet both military and civilian aircraft needs during periods of surge or peak demand. At present, there are only four large forging presses (two 35,000 ton and two 50,000 ton) in the U.S., and they are owned by the U.S. Air Force. It is this lack of forging capability which has produced the long lead times associated with titanium products (14:155). Because of lower costs and availability of imported sponge during the past, capital investment in new plants and modern equipment was discouraged, and as a result, an inability to satisfy demand surges for titanium sponge resulted. Although at present, it appears that domestic capacity to produce titanium sponge is adequate due to recent expansions, shortages could emerge given equipment failures in aging domestic production facilities and unexpected surges in demand (14:144))

In conclusion, the Bureau of Mines estimates an annual growth rate of 3.3 percent in the consumption of titanium materials through the year 2000. Hence, it appears that while geographic, political, economic, and environmental problems may have a negative impact on some supply sources,

there should be ample material to meet domestic requirements for titanium beyond 2000 (4:977).

Substitution Possibilities for Chromium, Cobalt, Manganese, and Titanium

A popular approach to reducing U.S. minerals and materials import dependency involves the substitution of materials that are plentiful and noncritical for those that are imported or scarce. Substitution appeals to many defense industry executives as a long term solution to our import dependency problem (12:20). Materials experts feel that the U.S. is moving into an "Age of Substitutability" where technical problems of substitution have been sufficiently solved to permit virtually unlimited interchangeability of materials. Current concern over U.S. materials import dependency may do much to hasten the arrival of the "Age of Substitutability" (12:2120).

Even though substitution may seem a simple concept, replacing one material with another is much more complex. Concerning the area of critical materials:

> The concept of substitution cannot be limited to the simple replacement of one material with another. It also involves the replacement of one process with another or changing the functional characteristics of a material or part [12:250].

Additionally, substitution is closely interwoven with changes involving conservation, design, and technology.

In order for a material to be substituted for another it must meet the following criteria:

Ready availability domestically in adequate

quantities, or (less than ideal) available from contiguous nations (primarily Canada and Mexico) or from overseas allies;

Physical and chemical properties, performance, and longevity comparable to the material of first choice;

Well established behavior and properties, and especially as a component in exotic alloys;

Ability for processing and fabrication with minimal changes in existing technology, capital plant, and processing and fabricating facilities [12:256].

The major problem facing critical and strategic materials substitution is substitutes rarely, if ever, meet the above criteria to any significant extent (12:256).

Each of the materials chromium, cobalt, manganese, and titanium will now be looked at in order to determine if substitute materials are now available or will be available in the near future to cut down on foreign dependence for these materials.

<u>Chromium</u>.

At present there is no substitute available for one-third of U.S. chromium usage that is devoted to high-strength, corrosion-resistant, oxidation-resistant or high-temperature alloys required for the manufacture of jet engines, petrochemical and power plant equipment. In addition, it would be impossible to manufacture stainless steel as we know it today without chromium (55:84).

There are situations where substitutes can be used for chromium but not without sacrificing quality and performance. Examples include:

Manganese and molybdenum for hardenability applications, but at increased costs;

Titanium or aluminum-coated low-chromium or no chromium alloys;

Ceramic and glass matrix composites, reinforced with silicon carbide or graphite fibers, for high-chromium nickel-base superalloys; and

Titanium or glass liners for stainless steel chemical process equipment [12:259].

Many experts believe that research and development to reduce chromium demand is centered on the short-term, especially in the military sector. These experts believe that a long-term, long-range research program is needed to develop substitutes for chromium in stainless steels and oxidation-resisting alloys (55:86).

Cobalt.

In the late 1970's, as the cobalt shortage peaked and the price reached over $50/pound, U.S. industries responded by searching for materials to substitute for cobalt in all areas of usage. As a result, various cobalt using industries found numerous possibilities for cobalt substitution (55:94). Cobalt can now be replaced in magnets without decreasing performance characteristics, and different types of carbide coatings on cutting tools can extend their lives and at the same time decrease cobalt requirements.

In 1982, at Los Alamos National Laboratory in New Mexico, a team of researchers developed an extremely hard metal that is made out of iron, tungsten, nickel, and boron

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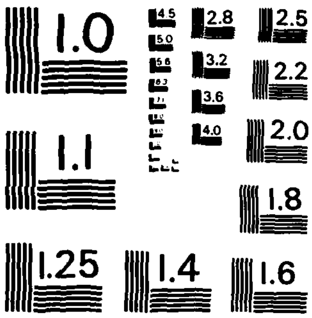

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

carbide that has superior abrasion properties and can be substituted for some cobalt based materials. The new material uses no cobalt, and its tungsten component can be substituted with molybdenum which is readily available in the United States (30:45).

At present, the U.S. Government and several cobalt using industries are sponsoring research to lower cobalt content in nickel based superalloys and to evaluate lower cobalt and cobalt free alloys, ceramics, and composites in gas turbine applications (55:95). If this research is successful, it will result in a major decrease in the amount of cobalt consumed by U.S. industries each year.

Manganese.

Experts from the Bureau of Mines indicate that there is no satisfactory substitute for manganese in its major applications at the present time due to the expense associated with obtaining a substitute. In addition, steel, as we know it today, could not be produced without manganese.

The search for a substitute for manganese is progressing slowly since research and development in this area has not been traditionally supported by the Department of Defense, primarily for economic reasons (55:107). It appears that as long as manganese can be obtained inexpensively, little research for a substitute will take place.

Titanium.

There appear to be many possible substitutes for titanium in the event of a national materials emergency. Such as:

> using graphite-fiber reinforced aluminum composites for jet engine fan blades; reinforced plastics for titanium alloys in aerospace structures; aluminum alloys made by rapid solidification techniques; parts formed by powder metallurgy techniques or near-net shape processing; precision cast components; and coated materials to prevent corrosion [13:262].

Although the above substitutes for titanium may be well and good for many industrial applications, according to a Bureau of Mines materials expert, there is essentially no substitute for titanium in many areas of the aerospace industry (13:262).

Conclusion.

This section briefly profiled the minerals which are of concern in this study and also provided information on substitutes that may be available in the event of a materials emergency in the United States. The next section will provide information on how vital these materials are to the United States and will give you some idea of what may happen if the United States is denied access to the materials discussed in this study.

IV. Risk Assessment and Impact

U.S. Preparedness For a Material Emergency

Critical materials are vital to U.S. industries, industrial growth, and national security. Many have a special role in supporting the defense industrial base and defense programs. The Defense Production Act of 1950 and the Strategic and Critical Materials Stockpiling Revision Act of 1979 form the legislative basis assuring supplies of needed materials are readily available for National Defense. Stockpile goals and status, the position of the Soviet Union, and profiles of cobalt, titanium, manganese, and chromium have already been presented. In the event of a declared emergency the National Defense Stockpile (NDS), in conjunction with the Defense Priorities System (DPS) and Defense Materials System (DMS), would control the flow of needed materials to essential industries. This section will review DPS and DMS which, together with the NDS, will provide the basis for risk assessment in the event of a supply interruption and present the views of many industrialists concerning the impact of strategic materials denial.

Defense Priority and Allocation System.

Title I of the Defense Production Act, as amended and supplemented by Executive Orders, authorizes the President to establish a system of priorities in contract performance necessary for National Defense. The system can require

contractors to accept and perform contracts to meet established priorities. It also authorizes the President to allocate materials and facilities for defense purposes (16:2). The two primary purposes of the priority and material allocation systems are to:

> insure the claimant agency programs are maintained on schedule by providing priority treatment for the purchase of products and materials by claimant agencies, contractors, subcontractors, and their suppliers [16:1]

And secondly,

> The operation of the systems results in the maintenance of an administrative means by which the total industrial resources of the country could be mobilized should the need arise [16:1].

Hence, the priority and allocation system provides for the timely flow of materials to projects of national priority.

The DMS/DPS systems currently in effect impacts programs in the Department of Defense (DoD), Department of Commerce (DoC), Department of Interior (DoI), the Department of Energy (DoE), Atomic Energy Programs of the Energy Research and Development Administration (ERDA), and various Sub-Claimant Agencies within DoD [16:10]. Figure 11 provides a list of programs covered by the priorities and allocation systems.

The Defense Materials System presently applies to four metals (steel, copper, aluminum, and nickel). Producers of these materials are required to reserve space on their order books up to a specified percentage of total productive

Column 1	Column 2	Column 3	
Program Identification	Program	Claimant Agency	Sub-Claimant Agency
	For Department of Defense and associated programs.		
A-1	Aircraft	Department of Defense.	Army. Navy (including Coast Guard). Air Force. Defense Supply Agency. CIA. FAA. NASA.
A-2	Missiles		
A-3	Ships		
A-4	Tank—Automotive		
A-5	Weapons		
A-6	Ammunition		
A-7	Electronic and communications equipment		
B-1	Military building supplies		
B-8	Production equipment (for defense contractor's account)		
B-9	Production equipment (Government owned)		
C-2	*Department of Defense construction*		
C-3	Maintenance, repair and operating supplies (MRO) for Department of Defense facilities.		
C-8	Controlled materials for Defense Industrial Supply Center (DISC).		
C-9	Miscellaneous		
	For U.S. Energy Research & Development Administration:		
E-1	Construction	U.S. Energy Research & Development Administration.	
E-2	Operations—including maintenance, repair and operating supplies (MRO)		
E-3	Privately owned facilities		
	For Energy Programs		
F-1	Certain items sponsored by the Federal Energy Administration for and related to construction of the Trans-Alaska Pipeline.	Department of the *Interior.*[1]	
F-2	Certain items sponsored by the Federal Energy Administration for and related to the development of Alaskan North Slope oil resources		
F-3	To maintain or further domestic energy exploration, production, refining, and/or transportation	Department of Energy	
F-4	To maintain or further conservation of energy supplies.		
F-5	Construction and maintenance of energy facilities.		
	For other Defense, Energy, Atomic Energy and related programs.		
B-5	Certain self-authorizing consumers (see sec. 7(d) of DPS Reg. 1, sec. 8(d) of DMS Reg. 1).	Bureau of Domestic Commerce.	
C-4	Certain munitions items purchased by friendly foreign governments through domestic commercial channels for export		
C-5	Canadian military programs		
C-6	Certain direct defense needs of friendly foreign governments other than Canada		
D-1	Controlled materials producers		
D-2[2]	Approved State and local civil defense programs		
D-3	Further converters (steel)		
D-4	Private domestic production		
D-5	Private domestic construction		
D-6	Canadian production and construction		
D-7	Friendly foreign nations (other than Canada) production and construction	Bureau of Domestic Commerce.	
D-8	*Distributors of controlled materials*		
D-9	Maintenance, repair and operating supplies (MRO) (see Dir. 1 to DMS Reg. 1)		
E-4	Canadian atomic energy program		
K-1	General Services Administration's supply distribution facility program		
AM	Aluminum controlled materials producers		
AM-9000	Aluminum controlled materials distributors		
FC	Further converters (steel and nickel alloys)		

Fig 11. Programs Covered by the DPS/DMS Source (16:11)

capacity for authorized controlled materials orders. The remaining space can be used to fill civilian orders (16:14).

These "set asides" should guarantee availability of adequate supply of these materials for authorized programs. Claimant agencies submit controlled material requirements for their programs on a quarterly basis to the Federal Emergency Management Agency. This agency inturn allocates appropriate quantities of steel, copper, aluminum, and nickel to the claimant agencies. This allotment constitutes authorization for use in approved programs [16:13]. The complement to the DMS is the defense priority system.

<u>The Defense Priority System</u>.

The Defense Priority System as designed to avoid delays on defense and defense related programs by requiring vendors to give preferential treatment to properly identified orders (17:50). Basically, the system requires contractors and suppliers to give priority to defense rated orders for production and or shipment over commercial and non-rated orders.

There are two types of preferential ratings given, DO and DX. The DO rated order takes precedence over unrated orders previously and subsequently received by the supplier. DX orders take precedence over all DO and non-ranked orders (17:52). This rating is usually reserved for defense programs of the highest national priority. An example being the B1-B Strategic Bomber. The DMS/DPS System has worked

well in the past ensuring the adequate supplies of steel, copper, aluminium, and nickel and the prioritization of government contracts. However, the strategic materials of chromium, cobalt, manganese, and titanium are not covered by the DMS/DPS system.

Risk Assessment

The U.S. and major industries (using cobalt, chromium, titanium, and manganese) vulnerability to supply disruptions can be assessed in terms of internal and external factors (15:241). External vulnerability relates to stability of supplies, concentration of the ore bodies, and the degree of our dependency. Whereas, internal vulnerability relates to the emergency preparedness and the possibilities of substitution. The level of internal vulnerability is a function of the National Defense Stockpile, the Defense Priorities Systems, and substitution. Table VIII summarizes the material previously presented in the study in terms of internal and external vulnerabilities for cobalt, chromium, manganese, and titanium. Reference to page fifty may be made to refresh your memory on the external factors.

Table IX presents the internal and external vulnerability risks levels associated with cobalt, chromium, titanium, and manganese.

Table VIII

Summary Data on Study Materials

	Cobalt	Chromium	Manganese	Titanium
EXTERNAL FACTORS				
High Import Dependency	Yes	Yes	Yes	Yes
Unstable Suppliers	Yes	Yes	Yes	No
Concentration of Reserves in Foreign Nations	Yes	Yes	Yes	No**
INTERNAL FACTORS				
Adequate Quantity in NDS	No	Yes	Yes***	No
Acceptable Quality of Material	No	No	Yes	*
Adequate U.S. Emergency Domestic Resources	No	No	No	Yes
Substitution Preparedness	No	No	No	No

* Not all titanium sponge in the NDS can be related to the original purchase specifications. The missing data thus limits the usefulness of much of the titanium sponge in the NDS.

** Ilmenite may be used instead of rutile ore for the production of titanium sponge, however, the process is more lengthy and costly. U.S. has sufficient domestic supplies of ilmenite ores.

*** Manganese ore provides the bulk of all manganese in the stockpile. This ore must first be processed to be useable by the steel industry. U.S. domestic production of high, medium, and low carbon ferromanganese was only 24 percent of U.S. consumption in 1981 as compared to 83 percent in 1970.

TABLE IX

Internal and External Vulnerability Risk Levels
For Study Materials

		Internal Vulnerability		
		Low	Medium	High
	High			chromium/manganese
External				
	Med		cobalt/titanium	
Vulnerability	Low			

Based on internal and external risk subfactors chromium and manganese were determined to be high in both internal and external risk, whereas, cobalt was determined to be a medium risk factor primarily because of its limited use throughout the economy. Titanium was also determined to be a medium risk for both internal and external factors primarily because of low amounts of stockpiled material and suspect quality of the material and friendly overseas supplies. The outlook for future use of these and other materials indicates a growth in demand over the next twenty years.

Outlook for Demand

Westerners have long believed in the value of human life. In the past 65 years the United States has been directly involved in four wars. The horrors of the recent

conflicts are vivid because, during the 60's, technology brought the war into our living rooms. The paralleled growth in weapons technology has led to a more sophisticated U.S. military; fewer but more technologically advanced weapons systems. Former Deputy Secretary of Defense, Paul Thayer, believes the U.S. will never match the Soviets tank for tank, missile for missile, or airplane for airplane. We have come to rely on technology "not only because we have a qualitative edge, but also because we place a high value on our most precious resource: people [3:6]." This emphasis on people, the quantitative edge, and technology will increase the demand for special materials in the future.

Economist and defense analyst, William Schneider views the situation similarly. In testimony before Congress, he indicates military personnel strength has declined 24 percent since FY 64. This diminishing force structure and the advancement of technology has required higher military equipment requirements (60:247). This reliance on high performance equipment according to Schneider inturn:

> Requires high performance inputs, including raw materials...Thus the outlook for the use of scarce raw materials is undiminished for as far as one can prudently predict [60:248].

The military, though not the largest user by volume of strategic materials, requires them in the technologically advanced weapons systems it produces today and will produce in the future. Strategic materials are requirements for national security. Any shortfall of strategic materials

will not only be felt economically by all sectors of the economy but will also be reflected in a compromised security position.

Impact of Materials Shortages

The opinions on the impact of a strategic materials supply interruption are varied; running from assurance to alarm. Two separate Congressional committees reported the following in December of 1980. A special study by the Joint Economic Committee of Congress reads:

> The degree of supply restriction entailed in price gouging and cartel like action would not have a serious effect on U.S. defenses. The portion of U.S. consumption of critical materials required of defense production __ generally required 10 percent to 20 percent in the event of war and about one half of that in peacetime... can be met from domestic production, stockpiling, and substitutes under any foreseeable supply restrictions [34:45].

This may be true for some strategic materials. It is not however true for chromium, cobalt, and manganese. The lack of U.S. reserves and irreplaceability of these materials in U.S. weapons makes the defense sector more vulnerable to supply interruptions. A differing opinion to that of the Joint Economic Committee was issued by the Defense Industrial Base Panel of the House Armed Services Committee. They found that:

> The shortage of critical materials, combined with a resulting dependence on uncertain foreign sources for these materials, is eroding the foundation of U.S. defense capabilities. These shortages are a monumental challenge to the Congress, the Department of Defense, the defense industry and the civilian economy [62:24].

The following views of many industrialists are similar to those held by the Defense Industrial Base Panel. E.F. Andrews, Vice President Materials and Services for Allegheny Ludlum Industries and long time champion of strategic materials, gave this testimony before Congress:

> One might ask--what is important about chromium or cobalt? I can do without trim on my automobile or my refrigerator. Well, in today's technology without chromium and cobalt we could not build a jet engine, build an automobile, run a train, build an oil refinery, or build a conventional or nuclear power station. We could not process food under present laws. We would have to repeal all our clean air and clean stream laws. We would have to repeal our sanitary hospital codes. We could not build a computer, cutting tool, mine tool, magnet, or process crude oil, just to mention a few things. Chrome is required in order to carry on our present standard of living under the technology we have. In fact, the National Research Council, in it's 18-month study, ended with a statement by Dr. Parker, of the University of California at Berkley, that the United States is strategically far more vulnerable to a long term chromium embargo than to an embargo of any other natural resource, including petroleum. In that report, Dr. Parker and his colleagues say that preparing the United States to overcome a chromium embargo will take a minimum of five and possibly up 15 years [60:239].

William Schneider testifying before Congress implied that failings in U.S. materials policy are being reflected in lessened national security. Supply shortfalls have induced stretched out procurements, multiyear lead times for critical items, and rapidly increasing cost for weapons systems. Present production rates for aircraft are approximately the same rates that existed in the 1930's. He feels the low production rates merely conceal the scope of the problem and any military requirement causing a surge

would quickly induce the production breakdown of military equipment requiring critical materials (60:253).

William A. Owczarski, Pratt and Whitney Aircraft Group, states their concern for a prolonged cobalt supply interruption and its impact on the U.S. airlines:

> In 1979, some 83 percent of the commercial flights in the United States were in aircraft equipped with our JT8D engine. On the average, these engines operate about 2500 hours per year and the first turbine vane, which is a 60 percent cobalt alloy, has a useful life of 10,000 hours before it is replaced. The pipeline for replacement is about 12 months long from our melting suppliers to delivery of spare vanes to the airlines. From the time cobalt should be cutoff from our melting suppliers, we could supply spare parts to our airline customers for only a year. At the end of that time, the JT8D powered fleet would start to be grounded at the rate of about 25 percent per year... The impact on our defense and commercial airline systems would be extremely serious [6e:T1U-2].

E.P. Whelan, Climax Molybdenum Company, states:

> There can be no question that the aircraft gas turbine industry is heavily dependent on chromium for its successful operation... The current price and availability of chromium has induced a false sense of security in this country, that has been historically difficult to disturb, and that is overdue for an infusion of realism [6e:T21-1].

Allen Gray, Technical Director of American Metals Society, says, "the cutoff of our chromium supply could be even more serious than a cutoff in our oil supply [6e:T17-3]."

James Santini, former chairman of the Subcommittee on Mines and Mining of the House Committee on Interior and Insular Affairs, expresses his concern on Soviet motives and materials shortages below:

> Control of southern Africa's strategic minerals would give the Soviets virtually total control of at least 15 of the most strategically important minerals in the world. Were they to obtain such control, the Soviets would be able to run a super cartel that would make OPEC (Organization of Petroleum Exporting Countries) a minor concern in comparison [27a:25].

Alexander Haig, then [1980] President and Chief Operating Officer of United Technologies Corporation, gave this response concerning a cutoff of cobalt and its effect on aerospace capacity:

> A lack of cobalt in the period ahead within a year would start a decline of about 25 percent a year of our production capability. It would have a devastating impact on us [33b:8].

Retired Admiral William C. Mott, Executive Director of the Council on Economics and National Security, presents a very gloomy picture:

> Like a mushroom cloud of an atomic explosion, shortages of strategic materials would spread from industry to industry and ultimately blanket every corner of our industrial base, threatening our standard of living, our very society itself.
>
> Shortfalls in just the four minerals discussed above [chromium, cobalt, manganese, and platinum] could cause shutdowns or slowdowns in such basic industries as: transportation, construction, manufacturing, electronics, steel, oil, chemicals, technology, even agriculture. That would throw untold millions of Americans out of work, shoot prices through the roof, render the dollar practically valueless. Even the nation's ability to defend itself would be in grave doubt. The resultant social and political repercussions in the country would defy imagination [32:138].

It is unlikely that an interruption of strategic materials would impact only the U.S. It is more likely to affect the U.S., Western Europe, and Japan. Former

Chancellor Helmut Schmidt expressed his concern over chromium and the West German Society before the U.S. Congress. He said:

> Shut me off from African chrome for a period of two years and you will decrease my employment by two million in a population of 60 million and cause my GNP to drop by 25 percent [18:T7-5].

In addition to these testimonials by experts, in the fields of defense analysis, economics, and strategic materials, various studies simulate the economic impact of a strategic materials denial. Identifying the specific and total impact of a sudden disruption in supply of a strategic material is quite difficult at best because there are a myriad of conditions and circumstances that would influence the ultimate impact of a disruption.

The Department of Commerce provides two analyses in its report on strategic materials and the aerospace industry. The first is a review and analysis of the 1973-1979 period when the United States experienced a cobalt supply shortage due to a disruption in mining activities in Zaire. The second analysis uses an econometric model to analyze the future world cobalt market and simulate a supply disruption.

In the first analysis, a review of Non-Centrally-Planned-Economies (NON-CPE) production of cobalt shows a marked decrease in production during the 1976-1978 time frame. See table X. The study states that Zairian cobalt production dropped considerably in 1976 and 1977 to about 60 percent of its 1974 production levels and Zambian production

in 1977-78 was approximately 20 percent below preceding years levels (14:85). Also, in 1977 the U.S. Government ceased the sale of "excess cobalt" from the NDS which had averaged six million pounds annually. Table X also shows new cobalt supplies (measured by adding production and stockpile releases) decreased approximately 14.6 million pounds on average or about 25 percent below the 1973-1976 time frame.

Table X

1973-1979 Cobalt Availability
(millions of pounds)

	Non-CPE Mine Production	NDS Release	Total Supply	Summary Total
1973	49.5	8.6	58.0	1973-75
1974	56.1	8.9	65.0	Average
1975	48.9	6.3	55.2	= 59.4
1976	39.6	6.7	46.3	1976-78
1977	40.4	0.1	40.5	Average
1978	47.8	0.0	47.8	= 44.9
1979	55.3	0.0	55.3	

Source (14:86)

A direct result of cobalt supply disruption is clearly seen in price changes between 1973 and 1979. Between 1973 and 1975 the producer price of cobalt fluctuated between $3.00 and $3.98/lb. Prices increased steadily to $4.44/lb in 1976, $5.58/lb in 1977, 6.85/lb in early 1978 followed by rapid jumps to $12.50, $18.00, and $20.00/lb by late 1978.

In 1979, the price level increased to $25.00/lb. During the late 70's the merchant price of cobalt approached $50.00/lb (14:86).

In response to these steady and significant price increases, total U.S. consumption of cobalt decreased on an average of 13 percent during the 1976 thru 1978 time frame. But, in 1979 as cobalt supplies increased to pre 1976 levels U.S. consumption increased to near the 1973-75 levels. The transportation sector, the primary user of cobalt, actually increased its use by about three percent between 1976-79 time frame while overall U.S. cobalt usage declined (14:87). The increased use of cobalt by the transportation sector during a period of declining supplies, suggests the importance of this mineral commodity and the transportation sector's willingness to pay a six fold increase in price.

A review and analysis of this period provides some insights into the possible reactions of using sectors and the U.S. Government in a future supply disruption (14:87-88).

-- Afrimet, the Zairian cobalt marketing company introduced an allocation system which allowed customers up to 70 percent of previous purchases.

-- Some of the U.S. aerospace companies entered the cobalt market. A function normally provided by the alloy companies.

-- The U.S. initiated an export monitoring system .

-- The market place responded by allocating cobalt to those

industries willing to pay the higher price. Naturally, this willingness to pay higher prices depended upon the industry's ability to substitute. Reaction of the aerospace industry seems to indicate the importance of cobalt in its production processes, as demonstrated by their willingness to pay the increased price.

-- Expenditures on cobalt increased approximately six fold during the 1975-79 time period when overall consumption decreased. In 1975, industry spent 75 million dollars for cobalt and in 1979, 475 million dollars.

-- Consumption patterns during the 1976-78 time frame indicate a substantial draw down of cobalt stocks.

-- Finally,

> It should be noted that these increased expenditures and reductions in consumption in some end use sectors resulted from a gradual three year period of market adjustment punctuated by one brief supply contingency. The cost of a single year disruption of similar magnitude would most likely be much higher [14:88].

The econometric model used by DOC to assess the impact of a future supply disruption is a supply demand function using simultaneous equations to balance the system. The demand equations reflect eight cobalt using sectors and the rest of the market economy while supply equations reflect such sources as Zaire, Zambia, Australia, Philippines and Canada (14:88). (For a more complete model description, assumptions, etc., see Critical Materials Requirements of the U.S. Aerospace Industry.) Two simulations are provided, normal market conditions and significant disruption of

cobalt supplies in 1985. The later simulation is of interest.

The significant disruption simulation reflects an unprecedented reduction in central African production; a 75 percent reduction in Zambian and Zairian cobalt reduction and a 50 percent unavailability of producer nation stocks. Figure 12 indicates a significant impact caused by a supply disruption.

Below is a summary of the model's projected impacts (14:92-95):

-- The market price of cobalt increases ten fold to approximately $150/lb.

-- Total U.S. consumption declines in the year of supply disruption and for several years thereafter (17 percent reduction in the year of disruption).

-- The transportation sector does not reduce usage as much as other sectors in the economy.

-- Cobalt expenditures increase from $350 million to about $3 billion (no disruption vs disruption scenarios) resulting in significant increases in prices of aerospace products.

-- Forced substitution would take place with likely inefficiencies.

-- Substitute product prices would likely be bid up resulting in higher price substitutes.

-- An increase in unemployment.

-- Possible spot shortages of materials which may impact on

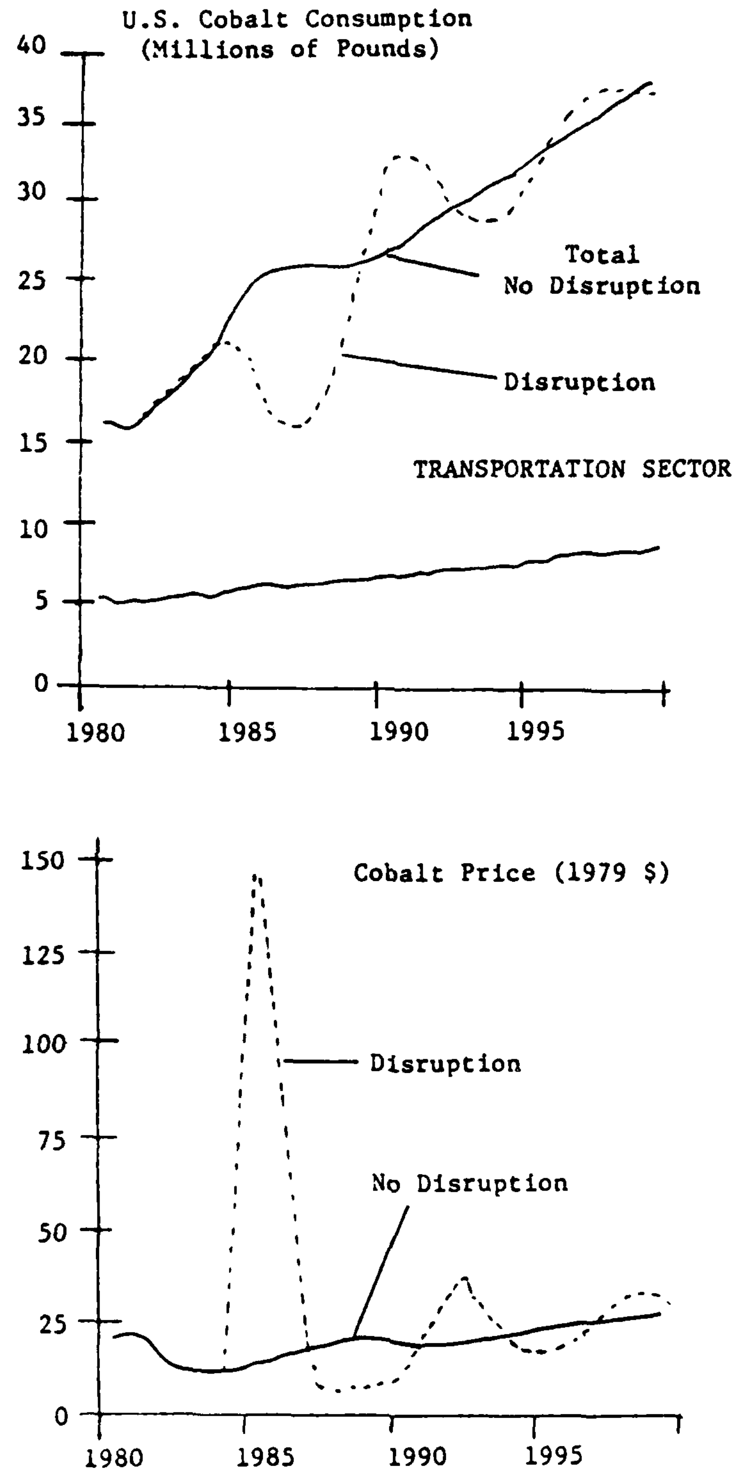

Fig 12. Comparison of 1980-2000 Cobalt Forecast and 1985 Disruptions Source (14:93)

DOD projects.

-- A likely decrease in the number of systems procured due to the simulated 10 fold price increase.

This study also makes similar conclusions regarding chromium.

> Concern in the chromium market revolves around the potential for disruption of production in Southern Africa. A significant reduction of chromite and or ferrochromium production could have a substantial impact on the market for chromium users... Although some reductions in chromium usage appear possible, it is doubtful whether the aerospace industry could reduce usage significantly more than ten percent in the short run without affecting product quality or quantity...
>
> However, a supply disruption can be expected to have a substantial financial impact on chromium users. Given the volatility of commodity markets, a significant disruption would greatly increase depending on the availability of stocks... In the short run, the division of these increased costs between manufacturer and consumers (including the airlines and the U.S. Government) is uncertain... [14:140-141].

It is likely, given a similar supply disruption to that simulated for cobalt, the consequences would be more severe in terms of additional social and economic costs because of the pervasiveness and importance of chromium throughout all sectors of the economy.

Several studies involving the economic impact of a chromium supply interruption have also been completed. Professor Roger Miller analyzed the economic impact from a renewed Rhodesian chromium embargo in 1975 entitled <u>The Economic Impact of U.S. Restrictions on Trade With Rhodesia: A Preliminary View</u>. The Department of the Interior also

completed a study of the same nature in 1975 entitled Critical Material Commodity Action Analysis. Finally, the Charles River Associates (CRA) performed a study entitled Policy Implications of Producer Country Supply Restrictions: The World Chromite Market. (Strategic Minerals: The Economic Impact of Supply Disruptions by James T. Bennett and Walter E. Williams summarizes the CRA study findings which are outlined below.

Bennett and Williams in reviewing the CRA study point out that one objective of the 1976 study was to "estimate the real economic costs to the economy in the event of an embargo." This study did not assume a supply disruption would happen but rather, assigned probabilities to likely events. The possibility of a disruption was assigned the probability of 0.3, and the probability that the disruption would continue for another year and for each additional year is 0.5 per year (1:45). Hence, the probability of a two year disruption is 0.3 times 0.5 or .15 and the probability of a three year disruption is 0.075. The following table provides the expected value costs based on two scenarios: A 15 percent supply disruption and a 26 percent supply disruption.

Table XI shows a 15 percent disruption scenario and a seven fold increase in the price of a short ton of contained chromium and the total expected economic loss is approximately $2.34 billion. Under the 26 percent disruption scenario, a 10 fold price increase takes place

Table XI

Charles River Associates Estimates of Price Changes and Expected Economic Losses of Chromium Supply Disruptions

	15% Supply Disruption		26% Supply Disruption	
Year	Price/Ton	Economic Loss ($ Mill.)	Price/Ton	Economic Loss ($ Mill.)
0	$ 220.0	$ 3.2	$ 222.0	$ 6.7
1	265.0	220.9	265.0	378.4
2	342.4	220.4	342.0	377.1
3	506.5	221.4	506.5	377.3
4	854.4	229.3	854.4	383.9
5	1439.8	257.6	1591.8	416.8
6	1211.6	247.4	2308.3	475.0
7	925.2	239.8	1666.7	445.8
8	696.5	238.0	1153.3	438.7
9	696.5	238.0	1153.3	438.7
10	696.5	238.0	1153.3	438.7

Source (1:45)

with a ten year expected economic loss of $4.2 billion. Bennett and Williams feel that although the CRA describes the import restriction of 15 and 26 percent as having severe consequences, they are very much understated because of the model's assumptions of a four year stockpile of chromium, constant price of substitutes, and only the availability of chromium would be affected (1:46).

A much more severe picture evolves if <u>actual losses</u> are considered instead of <u>expected losses</u>.

> If we assume that the likelihood of a disruption lasting for a period of, say, five years is one and adjust the CRA loss estimates accordingly... the five year economic loss with a 15 percent disruption is $22.6 billion and, with a 26 percent disruption, the loss $38.1 billion, substantially more than if expected cost alone are considered [1:46].

These economic losses can be translated into a decline in employment. If output were reduced by $22.6 and $38.1 billion respectively, over a period of five years, a loss of 1.25 and 2.1 million man years of employment would result (1:46). Again Bennett and Williams feel these estimates are understated because of the CRA model assumptions.

It is worth noting that the various models considered do not always predict the same degree of severity of the impact given a supply disruption however, we believe it is clear that given a relatively small reduction, 15 percent or so, in a strategic material, the economic impact will be wide spread with large reductions in output, significantly higher prices, and reductions in employment. Should there ever be a prolonged large scale reduction of strategic materials from southern Africa, severe economic hardships and dislocations of the labor force approaching catastrophic proportions would likely result. The United States and the rest of the Western world are not prepared to face a materials disruption on the scale just mentioned.

V. Findings And Recommendations

Findings

The findings and recommendations of this study presented below are based on thousands of pages of literature research, contributions of 15 major defense contractors, and four primary melt house suppliers to the defense industry and other sectors of the economy.

1. The National Defense Stockpile has been grossly mismanaged in the past 20 years. The Federal Ememrgency Management Agency (FEMA) estimates that had the status quo of 1962 been maintained, the cost of achieving current stockpile goals would be minimal and valuable surpluses of copper, aluminum, zinc, cobalt, nickel and lead would exist.

2. There is no real National Defense Stockpile Manager. Twenty six agencies are involved in stockpile management. This has resulted in a lack of direction and priority in the management of the NDS. Within GSA, the stockpile program is near the bottom of the priority list. The present structure of stockpile management is seriously lacking in a strong committment.

3. The vulnerability issue must be viewed in terms beyond raw materials supply because it also involves the vitality of the processing and manufacturing sectors which convert these materials into the products we need. The problem must

be approached on an international scale.

4. At present major aerospace defense contractors do not have plans to maintain a stockpile of raw materials used in the production of their products. They felt it was not in their economic interests to do so.

5. With one exception, we found the suppliers to aerospace industry are not carrying any excess inventories of raw materials. Carrying costs and interest rates make it nearly impossible to do so. One of the major steel producers attempts to keep their inventories to a minimum and would prefer to have their inventories on consignment.

6. Over the past 10 to 15 years the U.S. has experienced a tremendous reduction in ore processing capability particularly in chromium and manganese. The transfer of smelting facilities offshore increases America's vulnerability and further weakens an already deteriorating industrial base. Reprocessing of existing, stockpile ores in large quantities, to meet the high quality and stringent specifications of the defense industry can not be accomplished quickly.

7. The aerospace contractors could not provide any specific time frame, after which a material interruption occurred, when it would impact on government programs under contract. Nor were they able to identify specific increased costs or procurement times.

8. All interviewees expressed concern of an apparent lack of a National Policy on Strategic and Critical Materials. They felt it is the responsibility of the federal government to ensure adequate supplies of strategic and critical materials. This includes the purchase and maintenance of strategic materials for the National Defense Stockpile.

9. Our conversations with defense industry executives indicated that substantial financial incentives, to offset the risks and carrying costs for carrying excess inventories, are required to encourage users to maintain extra inventories of strategic materials.

10. There appears to have been insufficient government and industry interface in the past in determining and updating material specifications as indicated by the technical obsolescence of materials in the NDS.

11. The real mineral wealth of the United States is yet to be determined. Millions of acres of public land are off limits not only to mineral development but exploration as well. Only three tenths of one percent of the U.S. land mass has been disturbed by mining operations. The myopic approach of the federal government will only perpetuate our dependence on certain strategic materials, for example, cobalt and platinum.

12. Much of the material in the stockpile is unsuitable for national defense purposes. Defense industries require very

tight specifications and high purity requirements. Documentation on material specifications, quality, purity, etc., is missing on several minerals in the NDS, and some contamination exists, thus limiting the usefulness of NDS resources.

13. Ironically, the U.S. has contributed to the demise of its own domestic mining industries through its participation in the International Monetary Fund, which has lent billions of dollars to Third World Nations for mineral exploration and mining development.

14. Many allies of the U.S. are not actively engaged in stockpiling strategic materials needed for their own defense and economic stability. This will undoubtedly increase pressures on the United States to share resources from its national stockpile in the event of a major minerals disruption.

Recommendations

1. To prevent any further abuse of the National Stockpile the United States should establish a separate agency at the cabinet level whose charter would be to operate and maintain the National Defense Stockpile. It should be composed of representatives from government, industry, and academia who are most familiar with the strategic mineral problems facing the United States and its allies.

2. The United States should revitalize its industrial base

and particularly the mineral mining and processing industries. Through economic incentives and tax subsidies allowed under Title III of the Defense Production Act (DPA), the government could develop an effective program to encourage private industry development and expansion in the mining and processing industries.

3. The DoD should permit defense contractors to purchase raw materials and semi-processed materials under long lead time procurement agreements. Also, Title III of the DPA or tax subsidies could be used to encourage private industry's cooperation to hold excess dedicated government inventories of strategic materials for use in an emergency.

4. There is a lack of "corporate" knowledge concerning strategic materials substitution. It would be beneficial if there was a national strategic materials substitution data base to include information on new manufacturing processes and materials. This should be part of an organized effort to increase R&D activities on substitution technology.

5. The federal government should inventory all public lands to determine domestic availability of all strategic and critical materials.

6. The United States should develop a rational and coherent foreign policy with all foreign materials suppliers to ensure continued access to minerals and materials. We have in the past embargoed chrome from Rhodesia while at the same time we

purchased chrome from the Soviet Union.

7. To reduce strategic material usage and increase productivity, the Department of Defense should accelerate technology modernization programs in the defense industry.

8. The material in the National Defense Stockpile should be rotated to prevent technical obsolescence and deterioration. New materials purchased for the NDS must meet realistic specifications that will allow their use for a wide range of applications.

9. The President and/or Congress should make U.S. reliance on foreign sources for many important strategic materials a national security issue. This should serve to increase public awareness and gain support for this critical issue.

10. The government should replenish the stockpile first for the most vulnerable strategic materials on which the defense industry is most dependent.

11. The Defense Material System (DMS) must be expanded to include those materials on which the United States is most dependent and those whose shortages would cause the greatest economic or defense problems. Specific materials that should be added to the DMS are: chromium, cobalt, manganese, and titanium.

12. It is imperative that a coordinated international strategy, between the United States and its allies concerning

strategic material shortages, stockpiling, conservation and substitution technologies, be initiated because the problems concerning strategic materials are international in scope.

13. The United States Government should continue its efforts to obtain and maintain an Exclusive Economic Zone for deep sea mining purposes.

<u>Recommendations for Further Investigation and Study</u>

Recommendations for further investigation and additional study include:

1. The level of financial incentives required for suppliers to the defense industrial base to carry excessive stocks dedicated to defense programs

2. The development of a model to forecast the use of strategic materials for use in future weapon systems.

3. Investigate the ramifications and impact of liberalizing long lead procurement funding for forgings/parts made from strategic materials.

4. Investigate what role multiyear contracting could play in incentivizing contractors to procure strategic materials in advance of program requirements.

VI. Conclusion

When a nation no longer controls its destiny, it must with vigor and fortitude develop national policies to protect its security and economic base. That time is here and now. The U.S. is no longer the master of its fate. Nuclear proliferation, dependence on OPEC oil, and foreign strategic and critical materials essential to our defense and economic bases, has made this fact reality.

We have been stockpiling actively for over 40 years. However, the policies and efforts have not been coordinated. It has been reactionary rather than a deliberate planned effort. One of the greatest challenges facing the U.S. today is the development and implementation of an all encompassing rational coherent national policiy on strategic and critical materials. Because of past mistakes in policy and management, we have exposed ourselves to the mighty arm of the Soviet Union, which has as a long term national goal the domination of African States and the eventual consolidation of many of the strategic material areas under their control.

We are not guaranteed future access to the minerals on which the industrial base of the United States depends. The sooner Congress and the President realize this, and the American people become aware, the sooner a real policy that integrates strategic materials, national security, foreign policy, and economic issues can be implemented.

There are no strategic material shortages today. World supply and reserves are adequate for all materials for many years to come. However, it would take very little to precipitate a major materials crisis, given the level of U.S. dependence and the concentration of many ores in politically and economically unstable regions of central and southern Africa. The major push for economic, political, and racial reform in South Africa all point to a "Crisis Waiting To Happen," on the African continent. The scope of the crisis' impact on material dependent nations would be difficult to predict. However, the minerals involved, precipitating event, duration, and the world economy would all influence the eventual economic disruptions and international security implications. If the triggering event happens soon, it will find the United States and its allies unprepared, and with the international, economic, social and security consequences being very severe. The time for action is now.

Appendix A: Stockpile Inventory

Explanation of Table 2

The National Defense Stockpile total inventory as given in Table 2 excludes quantities that were sold but not shipped from depots to the purchasers. In the Statistical Supplement (available from the General Services Administration) the inventory is listed as "Total Inventory in Storage" with a separate line for "Unshipped Sales."

The Table 2 Inventory quantities combine stockpile and nonstockpile grade materials, while separate lines can be found for each type in the Statistical Supplement. Nonstockpile grade material may vary only slightly from the stockpile grade and in some cases is temporarily credited toward goals.

For some materials where a goal deficit occurs, the excess of another form of the material is held to offset the shortage as indicated in the footnotes at the end of Table 2. The term "offset" means allocating one form of a material for an equivalent amount of another form.

Materials are grouped by "families," and a summary line for each basic family group is included. The materials have been grouped in each family according to their status as raw materials, semifinished products or finished products that contain the same common ingredient. The values shown in the summary line for each family group are expressed in the basic unit common to all members of the group. In all but

three cases, this basic unit is the metal equivalent for each form. There is a different conversion factor for each form because each requires different technology and incurs different conversion losses.

Market values are prices at which comparable materials are being traded, or in the absence of trading, values are estimates. They are not necessarily the amount that would be realized if the material were sold.

The material in this appendix was extracted from the Federal Emergency Managment Agency publication, Stockpile Report to the Congress April-September 1983.

Abbreviations

AMA Lb	-Anhydrous Morphine Alkaloid (Pounds)
AvOz	-Avoirdupois Ounce
FL	-Flask (76-Pound)
KT	-Carat
LB	-Pound
LB Cb	-Pounds of Contained Columbium
LB Co	-Pounds of Contained Cobalt
LB Mo	-Pounds of Contained Molybdenum
LB Ta	-Pounds of Contained Tantalum
LB W	-Pounds of Contained Tungsten
LCT	-Long Calcined Ton
LDT	-Long Dry Ton
LT	-Long Ton
MT	-Metric Ton
PC	-Piece
SDT	-Short Dry Ton
ST	-Short Ton
ST Ni+Co	-Short Tons of Contained Nickel plus Cobalt
ST V	-Short Tons of Contained Vanadium
TrOz	-Troy Ounces

Table 2

NATIONAL DEFENSE STOCKPILE INVENTORY OF STRATEGIC AND CRITICAL MATERIALS

September 30, 1983

Commodity	Unit	Goal	Inventory	Value of Inventory (Millions $)	Quantity After Crediting Offset Excess	Quantity After Crediting Offset Deficit
1. Aluminum Metal Group	ST Al Metal	7,150,000	3,813,767	737.8		3,336,233
Alumina	ST	0	0	-		-
Aluminum	ST	700,000	2,080	3.3		697,920
Bauxite, Metal Grade, Jamaica Type	LDT	21,000,000	10,458,344	470.6		10,541,656
Bauxite, Metal Grade, Surinam Type	LDT	6,100,000	5,299,597	263.9		800,403
2. Aluminum Oxide, Abrasive Grain Group	ST Ab Grain	638,000	259,124	128.6		378,876
Aluminum Oxide, Abrasive Grain	ST	0	50,904	63.6	a	
Aluminum Oxide, Fused, Crude	ST	0	249,867	65.0	a	
Bauxite, Abrasive Grade	LCT	1,000,000	0	-		a
3. Antimony	ST	36,000	39,842	66.9	3,842	
4. Asbestos, Amosite	ST	17,000	42,540	29.8	25,540	
5. Asbestos, Chrysotile	ST	3,000	10,751	19.5	7,751	
6. Bauxite, Refractory	LCT	1,400,000	199,926	40.4		1,200,074
7. Beryllium Metal Group	ST Be Metal	1,220	1,061	198.8		159
Beryl Ore (11% BeO)	ST	18,000	17,987	21.8		13
Beryllium Copper Master Alloy	ST	7,900	7,387	87.6		513
Beryllium Metal	ST	400	229	88.9		171
8. Bismuth	LB	2,200,000	2,081,298	4.0		118,702
9. Cadmium	LB	11,700,000	6,328,809	5.9		5,371,191
10. Chromium, Chemical and Metallurgical Group	ST Cr Metal	1,353,000	1,324,923	979.1		28,077
Chromite, Chemical Grade Ore	SDT	675,000	242,414	13.6		c
Chromite, Metallurgical Grade Ore	SDT	3,200,000	2,488,043	237.6		c
Chromium, Ferro, High Carbon	ST	185,000	402,696	238.4	c	
Chromium, Ferro, Low Carbon	ST	75,000	318,892	418.0	c	
Chromium, Ferro, Silicon	ST	90,000	58,357	43.3		c
Chromium, Metal	ST	20,000	3,763	28.2		c
11. Chromite, Refractory Grade Ore	SDT	850,000	391,414	42.6		458,586

Table 2 (continued)

	Commodity	Unit	Goal	Inventory	Value of Inventory (Millions $)	Quantity After Crediting Offset Excess	Quantity After Crediting Offset Deficit
12.	Cobalt	LB Co	85,400,000	45,995,714	574.9		39,404,286
13.	Columbium Group	LB Cb Metal	4,850,000	2,532,419	23.3		2,317,581
	Columbium Carbide Powder	LB Cb	100,000	21,372	.6		78,628
	Columbium Concentrates	LB Cb	5,600,000	1,806,218	15.5		d
	Columbium, Ferro	LB Cb	0	930,911	5.6	d	
	Columbium, Metal	LB Cb	0	44,851	1.6	d	
14.	Copper	ST	1,000,000	29,048	43.9		970,952
15.	Cordage Fibers, Abaca	LB	155,000,000	0	-		155,000,000
16.	Cordage Fibers, Sisal	LB	60,000,000	0	-		60,000,000
17.	Diamond, Industrial Group	KT	29,700,000	37,753,967	418.8	8,028,490	
	Diamond Dies, Small	PC	60,000	25,473	1.1		34,527
	Diamond, Industrial, Crushing Bort	KT	22,000,000	22,192,880	38.8	192,880	
	Diamond, Industrial, Stones	KT	7,700,000	15,535,614	378.9	7,835,614	
18.	Fluorspar, Acid Grade	SDT	1,400,000	895,983	161.3		504,017
19.	Fluorspar, Metallurgical Grade	SDT	1,700,000	411,738	51.5		1,288,262
20.	Graphite, Natural, Ceylon, Amorphous Lump	ST	6,300	5,499	10.7		801
21.	Graphite, Natural, Malagasy, Crystalline	ST	20,000	17,899	53.7		2,101
22.	Graphite, Natural, Other Than Ceylon & Malagasy	ST	2,800	2,804	2.0	4	
23.	Iodine	LB	5,800,000	7,510,930	51.8	1,710,930	
24.	Jewel Bearings	PC	120,000,000	71,783,893	61.6		48,216,107
25.	Lead	ST	1,100,000	601,025	282.5		498,975
26.	Manganese, Dioxide, Battery Grade Group	SDT	87,000	218,205	20.6	131,205	
	Manganese, Battery Grade, Natural Ore	SDT	62,000	215,394	16.4	e	
	Manganese, Battery Grade, Synthetic Dioxide	SDT	25,000	3,011	4.2		e

Table 2 (continued)

	Commodity	Unit	Goal	Inventory	Value of Inventory (Millions $)	Quantity After Crediting Offset Excess	Deficit
27.	Manganese, Chemical & Metallurgical Group	ST Mn Metal	1,500,000	1,958,966	488.7	393,038	
	Manganese Ore, Chemical Grade	SDT	170,000	194,653	16.0	24,653	
	Manganese Ore, Metallurgical Grade	SDT	2,700,000	3,367,103	160.2		f
	Manganese, Ferro, High Carbon	ST	439,000	599,978	262.5	f	
	Manganese, Ferro, Low Carbon	ST	0	0	-	-	
	Manganese, Ferro, Medium Carbon	ST	0	28,920	20.8	f	
	Manganese, Ferro, Silicon	ST	0	23,574	9.9	f	
	Manganese Metal, Electrolytic	ST	0	14,172	19.3	f	
28.	Mercury	FL	10,500	178,315	53.5	167,815	
29.	Mica Muscovite Block, Stained & Better	LB	6,200,000	5,212,445	27.8		987,555
30.	Mica Muscovite Film, 1st & 2nd Qualities	LB	90,000	1,226,297	14.4	1,136,297	
31.	Mica Muscovite Splittings	LB	12,630,000	18,046,225	27.1	5,416,225	
32.	Mica Phlogopite Block	LB	210,000	130,745	.7		79,255
33.	Mica Phlogopite Splittings	LB	930,000	1,673,234	3.3	743,234	
34.	Molybdenum Group	LB Mo	0	0	-	-	
	Molybdenum Disulphide	LB Mo	0	0	-	-	
	Molybdenum, Ferro	LB Mo	0	0	-	-	
35.	Morphine Sulphate and Related Analgesics	AMA LB	130,000	71,303	26.2		58,697
	Crude	AMA LB	0	31,795	4.9	g	
	Refined	AMA LB	130,000	39,508	21.3		g
36.	Natural Insulation Fibers	LB	1,500,000	0	-		1,500,000
37.	Nickel	ST Ni+Co	200,000	32,209	149.8		167,791
38.	Platinum Group Metals, Iridium	Tr Oz	98,000	23,590	7.8		74,410
39.	Platinum Group Metals, Palladium	Tr Oz	3,000,000	1,255,008	191.4		1,744,992
40.	Platinum Group Metals, Platinum	Tr Oz	1,310,000	452,642	194.2		857,358
41.	Pyrethrum	LB	500,000	0	-		500,000
42.	Quartz Crystals	LB	600,000	2,060,336	12.4	1,460,336	
43.	Quinidine	Av Oz	10,100,000	1,874,504	6.7		8,225,496

Table 2 (continued)

Commodity	Unit	Goal	Inventory	Value of Inventory (Millions $)	Quantity After Crediting Offset Excess	Quantity After Crediting Offset Deficit
44. Quinine	Av Oz	4,500,000	3,246,164	8.2		1,253,836
45. Ricinoleic/Sebacic Acid Products	LB	22,000,000	12,524,242	9.2		b
46. Rubber	MT	864,000	120,875	159.8		743,125
47. Rutile	SDT	106,000	39,186	12.7		66,814
48. Sapphire and Ruby	KT	0	16,305,502	.2	16,305,502	
49. Silicon Carbide, Crude	ST	29,000	80,550	36.2	51,550	
50. Silver, Fine	Tr Oz	0	137,505,946	1,651.4	137,505,946	
51. Talc, Steatite Block & Lump	ST	28	1,081	.4	1,053	
52. Tantalum Group	LB Ta Metal	7,160,000	2,426,387	127.8		4,733,613
Tantalum, Carbide Powder	LB Ta	0	28,688	4.7	h	
Tantalum Metal	LB Ta	0	201,133	44.2	h	
Tantalum Minerals	LB Ta	8,400,000	2,584,195	78.9		h
53. Thorium Nitrate	LB	600,000	7,131,812	19.6	6,531,812	
54. Tin	MT	42,700	191,310	2,558.7	148,610	
55. Titanium Sponge	ST	195,000	32,331	353.4		162,669
56. Tungsten Group	LB W Metal	50,666,000	78,870,238	484.7	28,204,238	
Tungsten Carbide Powder	LB W	2,000,000	2,032,942	23.3	i	
Tungsten, Ferro	LB W	0	2,025,361	24.8	i	
Tungsten, Metal Powder	LB W	1,600,000	1,898,911	24.5	i	
Tungsten Ores & Concentrates	LB W	55,450,000	85,679,220	412.1	i	
57. Vanadium Group	ST V Metal	8,700	541	6.5		8,159
Vanadium, Ferro	ST V	1,000	0	-		1,000
Vanadium Pentoxide	ST V	7,700	541	6.5		7,159
58. Vegetable Tannin Extract, Chestnut	LT	5,000	14,732	9.9	9,732	
59. Vegetable Tannin Extract, Quebracho	LT	28,000	134,322	92.3	106,322	
60. Vegetable Tannin Extract, Wattle	LT	15,000	15,001	10.6	1	
61. Zinc	ST	1,425,000	378,316	350.9		1,046,684

Offsets

a. Aluminum Oxide, Fused Crude: Hold 50,904 ST of aluminum oxide abrasive grain and 249,867 ST of aluminum oxide fused crude as offset against 379,253 LCT of bauxite abrasive grade.

b. Ricinoleic/Sebacic Acid Products: Sebacic acid inventory is credited toward goal at the rate of 2.5 to 1.

c. Chromium Group, Chemical and Metallurgical Grades: Metallurgical grade ore goal is 3,200,000 SDT of specification grade; inventory 1,956,824 SDT; shortfall 1,243,176 SDT.

(1) Hold 217,695 ST of Fe Cr high carbon against shortfall of 544,238 SDT of specification grade ore.
(2) Hold 243,892 ST of Fe Cr low carbon against 609,730 SDT of specification grade ore.
(3) Hold 89,208 SDT of non-specification grade metallurgical ore against the balance of the 89,208 SDT specification grade ore shortfall.
(4) Hold 47,466 SDT of non-specification grade metallurgical ore against a shortfall of 31,644 ST of Fe Cr Si.
(5) Hold 56,830 SDT of non-specification grade metallurgical ore against a shortfall of 16,237 ST of chromium metal.
(6) Hold 337,715 SDT of non-specification grade metallurgical ore against 337,715 SDT of chemical grade ore shortfall.

d. Columbium Group:

(1) Hold 930,911 pounds Cb as Fe Cb against 1,095,189 pounds Cb as concentrates.
(2) Hold 44,851 lb Cb as Cb metal against 52,766 lb Cb as concentrates.

e. Manganese, Dioxide, Battery Grade Group:

Hold 21,989 SDT of manganese, battery grade, natural ore against a shortfall of 21,989 SDT of manganese, battery grade, synthetic dioxide.

f. Manganese Group, Chemical and Metallurgical Grades: Metallurgical grade ore goal is 2,700,000 SDT; inventory 2,409,160 SDT; shortfall 290,840 SDT of stockpile grade ore.

(1) Hold 14,172 ST of Mn metal against 35,430 SDT of metallurgical ore.
(2) Hold 23,574 ST of Fe Mn Si against 42,433 SDT of metallurgical ore.
(3) Hold 28,920 ST of Fe Mn medium carbon against 57,840 SDT of metallurgical ore.
(4) Hold 77,569 ST of Fe Mn high carbon against 155,138 SDT of metallurgical ore.
(5) Hold remaining 83,304 ST of Fe Mn high carbon against reduction of ore value in desired inventory mix.

g. Opium: Hold 31,795 AMA lb of opium gum against 31,795 AMA lb of opium salt goal.

h. Tantalum Group:

(1) Hold 201,133 lb Ta as Ta metal against 237,337 lb Ta as concentrates.
(2) Hold 28,688 lb Ta as Ta C against 33,852 lb Ta as concentrates.

i. Tungsten Group:

(1) WC powder goal is 2,000,000 lb W; stockpile grade inventory 1,921,167 lb W; shortfall 78,833 lb W. Hold 111,775 lb W as non-specification grade WC to offset 78,243 lb W as WC specification grade (assume 70% recovery of usable W).

(2) W metal powder goal is 1,600,000 lb W; inventory stockpile grade 1,566,964 lb W; shortfall 33,036 lb W. Non-stockpile grade W metal powder inventory is 331,947 lb W. Assume 70% recovery as usable material, then 331,947 x .70 = 232,363 lb W. Hold 47,194 lb W as non-specification grade powder to offset shortfall of 33,036 stockpile grade W powder.

(3) Hold balance of non-stockpile grade W powder 232,363 - 33,036 = 199,327 lb W as powder against 234,209 lbs W as concentrate.

(4) Hold 840,752 lbs W as Fe W stockpile grade against 987,884 lb W as concentrate. Hold 1,184,609 lb W nonstockpile grade Fe W at 70 percent recoverable against 974,341 lb W concentrate.

Appendix B: U.S. Net Import Reliance Of Metals and Minerals

U.S. NET IMPORT RELIANCE 1/ OF METALS AND MINERALS AS A PERCENT OF APPARENT CONSUMPTION 2/
(In percent. Based on net imports of metals, minerals, ores, and concentrates.)

Metals and Minerals	1981	1982	1983 e/	Major Foreign Sources (1979-[illegible])
Aluminum (metal)	E	7	18	Canada, Ghana, Venezuela, Japan
Antimony	48	51	52	Metal: Bolivia, China, Bel.-Lux., Mexico Ores: Bolivia, Mexico, Canada, Rep. of South Africa Oxide: Rep. of South Africa, China, Bolivia, France
Arsenic	W	W	W	Sweden, Mexico, France, Canada
Asbestos	73	74	65	Canada, Rep. of South Africa.
Barite	40	55	64	China, Peru, Chile, Morocco
Bauxite and alumina	94	96	96	Bauxite: Jamaica, Guinea, Suriname Alumina: Australia, Jamaica, Suriname
Beryllium	W	W	W	China, Brazil, Rep. of South Africa, Rwanda
Bismuth	W	W	W	Peru, Mexico, United Kingdom, Fed. Rep. of Germany
Boron	E	E	E	Colemanite and Ulexite: Turkey
Bromine	E	E	E	Israel, United Kingdom, Netherlands, France
Cadmium	53	73	69	Canada, Australia, Mexico, Rep. of Korea
Cement	4	5	4	Canada, Japan, Mexico, Spain
Cesium (compounds)	100	100	100	Fed. Rep. of Germany, United Kingdom
Chromium	90	85	77	Chromite: Rep. of South Africa, U.S.S.R., Philippines Ferrochromium: Rep. of South Africa, Yugoslavia, Zimbabwe
Clays	E	E	E	United Kingdom, Canada, Fed. Rep. of Germany, Mexico
Cobalt	92	92	96	Zaire, Zambia, Bel.-Lux., Canada, Japan, Norway
Columbium	100	100	100	Brazil, Canada, Thailand
Copper	5	1	17	Chile, Canada, Peru, Zambia
Corundum	100	100	100	Rep. of South Africa
Diamond (industrial stone)	100	100	100	Rep. of South Africa, Zaire, Bel.-Lux., United Kingdom
Diamond (bort, powder, dust)	E	E	E	Ireland, Rep. of South Africa, Japan, Bel.-Lux., Switzerland
Diatomite	E	E	E	Mexico
Feldspar	E	E	E	Canada, Norway, Sweden
Fluorspar	83	83	W	Mexico, Rep. of South Africa, China, Italy
Gallium	NA	NA	NA	Switzerland, Canada, Fed. Rep. of Germany, China
Garnet	E	E	E	None
Gem stones	100	100	100	Rep. of South Africa, Bel.-Lux., Israel, India
Germanium	NA	NA	NA	Bel.-Lux., China, Switzerland, Fed. Rep. of Germany
Gold	15	32	21	Canada, Switzerland, (mostly Rep. of South Africa origin), U.S.S.R.
Graphite (natural)	100	W	W	Mexico, China, Brazil, Madagascar, Rep. of Korea
Gypsum	37	36	39	Canada, Mexico, Spain
Hafnium	W	W	W	France, Fed. Rep. of Germany, United Kingdom
Helium	E	E	E	None
Ilmenite	52	75	W	Australia, Canada, Rep. of South Africa
Indium	NA	NA	NA	Bel.-Lux., Peru, Japan, United Kingdom
Iodine	W	W	W	Japan, Chile
Iron ore	22	34	37	Canada, Venezuela, Brazil, Liberia
Iron and steel	13	24	13	Europe, Japan, Canada
Iron and steel scrap	E	E	E	Canada
Iron and steel slag	NA	NA	NA	Not available
Kyanite & related minerals	E	E	E	Not available
Lead (metal)	1	3	11	Canada, Mexico, Australia, Peru
Lime	2	2	2	Canada, Mexico
Lithium	E	E	E	Insignificant

U.S. NET IMPORT RELIANCE 1/ OF METALS AND MINERALS AS A PERCENT OF APPARENT CONSUMPTION 2/
(In percent. Based on net imports of metals, minerals, ores, and concentrates.)

Metals and Minerals	1981	1982	1983 e/	Major Foreign Sources (1979-1982)
Magnesium	E	E	E	Canada, Norway, France, Netherlands
Magnesium compounds	2	4	2	Ireland, Greece, Japan, India
Manganese	98	99	99	Ore: Rep. of South Africa, Gabon, Australia, Brazil Ferromanganese: Rep. of South Africa, France
Mercury	44	31	25	Japan, Spain, Canada, Italy
Mica (natural) scrap flake	E	E	E	Canada, India, Brazil
Mica (natural) sheet	100	100	100	India, Brazil, Belgium
Molybdenum	E	E	E	Chile, Mexico, Canada
Nickel	75	76	77	Canada, Australia, Norway, Botswana
Nitrogen (fixed)	5	8	11	Canada, Trinidad and Tobago, U.S.S.R., Mexico
Peat	34	29	36	Canada, Fed. Rep. of Germany
Perlite	E	E	E	Greece
Phosphate rock	E	E	E	Morocco, Netherlands Antilles, Mexico
Platinum-group metals	84	80	84	Rep. of South Africa, U.S.S.R., United Kingdom
Potash	65	65	75	Canada, Israel
Pumice & pumicite	15	22	30	Greece, Italy
Quartz crystal-industrial	NA	NA	NA	Brazil
Rare-earth metals	14	11	18	Monazite: Australia, Malaysia
Rhenium	W	W	W	Chile, Fed. Rep. of Germany
Rubidium	NA	NA	NA	Canada
Rutile	W	W	W	Australia, Sierra Leone, Rep. of South Africa
Salt	8	11	8	Canada, Mexico, Bahamas, Chile
Sand and gravel (construction)	E	E	E	Canada
Selenium	45	55	37	Canada, Japan, United Kingdom, Bel.-Lux., Fed. Rep. of Germany
Silicon	17	23	30	Canada, Brazil, Norway, Venezuela
Silver	53	55	61	Canada, Mexico, Peru, United Kingdom
Sodium carbonate	E	E	E	Canada
Sodium sulfate	10	26	29	Canada, Belgium, Mexico, United Kingdom
Stone (crushed)	-	-	-	Canada, Bahamas
Stone (dimension)	43	51	55	Italy, Canada, Mexico
Strontium	100	100	100	Mexico
Sulfur	5	4	16	Canada, Mexico
Talc and pyrophyllite	E	E	E	Italy, Canada, France
Tantalum	92	92	91	Thailand, Canada, Malaysia, Brazil
Tellurium	W	W	W	Canada, Hong Kong, United Kingdom
Thallium	W	100	100	Fed. Rep. of Germany, Bel.-Lux., Norway
Thorium	100	100	100	France, Netherlands, Canada, Malta
Tin	77	68	72	Malaysia, Thailand, Bolivia, Indonesia
Titanium (metal)	W	W	W	Japan, China, U.S.S.R.
Tungsten	50	46	39	Canada, Bolivia, China
Vanadium	34	24	52	Rep. of South Africa, Canada, Finland
Vermiculite	E	E	E	Rep. of South Africa, Brazil
Yttrium	100	100	100	Monazite: Australia, Malaysia Yttrium concentrate: Malaysia, Canada, Japan
Zinc	64	58	66	Ore & Concentrates: Canada, Peru, Mexico Metal: Canada, Spain, Australia, Peru
Zirconium	W	W	W	Zirconium: France, Japan, Canada Zircon: Australia, Rep. of South Africa

e/ Estimated.
E Net exports.
W Withheld.
NA Not available.
\- None.

1/ Net import reliance = imports - exports + adjustments for Government and industry stock changes.
2/ Apparent consumption = U.S. primary + secondary production + net import reliance.

Appendix C: Soviet Minerals Policy

An examination of Soviet minerals policy should provide a general idea as to how the U.S.S.R. uses its vast mineral resources to serve its objectives. The mineral policy will be examined therefore with regard to several Soviet goals:

- Pursuit of self-sufficiency in minerals.
- Development of trade as a means of obtaining needed foreign exchange to finance large imports of goods, services, and technology from the West in addition to meeting the mineral needs of the Comecon countries.
- Gaining political influence around the world and increasing integration of the Comecon countries' economies with that of the Soviet Union.

Pursuit of Self-Sufficiency

Soviet resource policy has been characterized by a willingness to incur substantial costs in order to promote a balanced development of all the materials required by an industrialized society. The economic principles of comparative advantage have had little influence. With nonfuel minerals unmatched elsewhere in the world, low-cost labor, and low consumption, the U.S.S.R. has become the most self-sufficient among the world's leading industrialized nations. Only for a few minerals--bauxite and alumina, cobalt, tin, tungsten, fluorspar, and mica--does the U.S.S.R. have some degree of import dependency.

The U.S.S.R. is the leading world producer of iron ore, manganese ore, platinum group metals, petroleum, steel, potassium salts, asbestos, and cement. It occupies second place, following the United States, in world output of aluminum, lead, natural gas, coal and phosphate rocks. It ranks second, after Canada, in the production of nickel, and follows South Africa in gold and chromium ore output.

To achieve its world position as a leading mineral producer with a high degree of self sufficiency, mineral development has been given a key place in the Soviet economic policy. Very large sums are spent on mineral exploration and production. Wide-ranging programs for investigating promising but as yet unconfirmed deposits suggest that new reserves will continue to be found. Given the evidence of extensive mineralization in the already surveyed areas of the Soviet Union, the very large unsurveyed areas will likely provide major discoveries in the future.

Also, Soviet efforts to open up new sources of mineral supply have contributed to programs of regional economic development, another Soviet objective. In some remote areas, mining and ore processing constitute the only significant economic activities; in others they help provide the nucleus for manufacturing and other economic activities; in all areas they help establish the Soviet presence.

The self-sufficiency picture is quite different when semi-manufactures such as high-quality rolled steel, large-

diameter steel pipes, etc., are included, since the Soviet Union is dependent on imports to meet requirements for these commodities.

The question arises to what extent can the current self sufficiency be maintained in the future. The cost of mineral development is rising. Additional labor, capital, and advanced technology and equipment are required as older deposits become depleted and new deposits are located far from population and consumption centers in areas with severe climatic conditions. Although decisions regarding mineral production are based more on whether they further Soviet programs than on laws of comparative advantage, the rising costs do act as a constraint by further reducing the supply of limited inputs available for other purposes.

These products were highlighted by the "Basic Guidelines for the Social and Economic Development of the U.S.S.R. for 1981-85 and the Period up to 1990," offering the basic outlines of the Eleventh Five-Year Plan. The document declared that under the previous 5-year plan "certain economic and social problems" had been complicated by a depletion of old mineral deposits and by the transfer of main centers of mining to the Soviet east and north, far from the centers of population and industry. The document further recognized that this shift would continue and even accelerate, not only in the area of fuels and other energy sources by also in nonfuel mineral resources. Additionally, the "Basic Guidelines" admitted that extractive technologies

needed improvement and that waste was a major problem (7).

With regard to resource depletion, the U.S.S.R. has often continued to work a deposit even after it has ceased to offer economic returns. Application of additional quantities of labor have regularly served to increase metal output at mines beset by decreasing ore quality. With an impending labor shortage, this solution is no longer readily available.

The trend of northward and eastward movement of the centers of almost all of the extractive industries and the continued requirement for expanded production will accentuate labor and transportation problems. Most of the Soviet east and north is inhospitable and lacking in social amenities. In spite of many incentives such as preferential salaries, superior holiday and travel arrangements, and early retirement benefits, labor shortages and high turnover plague all Soviet industries in these areas, including the extractive industries. Additional strain is also put on the Soviet railroad system to move minerals. Completion of the Baikal-Amur railroad (BAM) will open access to new territory, but transport capacity westward will not increase until double tracking of the Chelyabinsk-Tashkent line is undertaken. One recent article pointed out that the BAM will necessitate the construction of a "meridian line northward" as well as other trunk lines to bring "a number of large mineral deposits" into production. Aware of the difficulties caused by railroad problems, the Eleventh Five-

Year Plan calls for 3,600 kilometers of new line and 5,000 kilometers of double tracking.

Even in the unlikely event that increased incentives and more railroad track can ameliorate the labor and location problems, archaic technologies and waste would remain. Ore recovery is low at mines; efficiency is poor at concentration plants and at smelters; the transportation system loses great quantities of metals and minerals; and end products are inefficiently used.

MINERAL TRADE POLICY

Although self-sufficiency in minerals is an important Soviet goal, it would be an exaggeration to say "at any cost." Approximately 11% of total Soviet imports are minerals. When extremely high costs have been encountered, the Soviets have been willing to accept some degree of reliance on foreign supplies. Among tin consumers, the Soviet Union has regularly relied on imports for about a quarter of its tin needs, reflecting its reluctance to push tin development projects in high cost areas. Also, growth of the aluminum industry in the past 15 years has been made possible by a decision to import steadily increasing amounts of raw materials. In addition , the Soviets also resort to importing minerals for which they are not usually dependent on foreign sources to supply regions far from the Soviet source of supply, to overcome temporary supply breakdowns, or as a political gesture to help friendly countries.

Mineral export plays a much larger role in trade than mineral imports. Without mineral exports (particularly fuel exports), the Soviet Union could not pay for high-technology machinery and equipment, complete industrial plants, and acquire high-quality steel products and technology that it imports from the West. A large percentage of exports are not actually surpluses and could easily be consumed in the domestic economy. Since certain commodities are exported to meet hard currency requirements, the amount of a commodity exported can depend on the price it sells for on Western markets.

Emphasis on raw material exports is not universally applauded in the Soviet Union. All things considered, the Soviet Union would rather hold onto its natural resources than export them. As long as it must avail itself of advanced Western technology for more efficient mining as well as manufacturing and as long as it is unable to produce and sell more sophisticated manufactured goods, the Soviet Union has a strong incentive to continue exporting raw materials.

Export of raw materials to Comecon countries, particularly to East Europe, is another important aspect of Soviet nonfuel mineral trade policy. In return, the Soviets import Eastern European manufactured goods that are of higher quality than those produced domestically. In addition, this trade is not paid for in hard currency. In 1979, 93% of the exported iron ore was shipped to Comecon

member countries. For manganese ore, the share was also 93%, copper about 65%, lead 90%, crude zinc 60% to 70%, and primary aluminum about 65%.

Looking at the Comecon side of minerals trade, the U.S.S.R. provides nearly 100% of their imports of pig iron, about two-thirds of their rolled ferrous metals and phosphate fertilizers, about 60% of their manganese ore, and up to 90% of their iron ore. Substantial quantities of iron ore, rolled ferrous metals, and chemical products are to be supplied also in 1981-85. Of the six East European Comecon members only Romania depends more on the West than on the U.S.S.R. for raw materials. Given shortages of hard currency, it will be difficult for these countries to purchase nonfuel minerals in the world market if Soviet supplies are not adequate.

The U.S.S.R.-Comecon relationship up until 1973 was not disadvantageous to the Soviet Union, since it supplied its allies with energy and raw materials in return for their industrial goods. Following the dramatic rise in oil prices in 1973, the situation changed. The Soviets found that they were selling their allies raw materials that they could sell more profitably on the world market--in effect, they were giving a subsidy. Yet, for political reasons, the U.S.S.R. can ill afford to reverse this trend. Politically motivated economic subsidies occurred even before the sharp oil price hike. Such an economic subsidy to Czechoslovakia's new regime had been used in 1968 by the Soviets as the principal

means of softening the impact of their intervention in the country.

Even if secondary, economic considerations have been steadily rising in importance, the question arises whether at a certain point the economic factor does in fact become overriding and hence whether the decision-makers begin to act accordingly. This in fact seems to be the evolving trend; the Soviets have begun to encourage Comecon countries to seek sources other than the U.S.S.R. for raw materials (particularly petroleum). The Soviet Union is also calling on East European countries to aid in Soviet mineral development. Joint projects are being initiated with Comecon countries, the latter providing labor and capital goods to open new mines or build plants; e.g., the steelworks in the Kursk area and the opening up of copper-molybdenum deposits in Mongolia.

As stated previously, the Soviets have also found it necessary to import minerals, including bauxite and alumina, antimony, some copper, cadmium, lead and zinc, molybdenum, tin, tungsten, and nonmetallic minerals such as barite, mica, and fluorspar. It is difficult to tell in all cases whether Soviet imports signify a supply problem or are a political gesture to help some developing country rid itself of a surplus. In the case of production disruptions, which are a common occurance, the Soviets have turned to the foreign market. In some instances they have switched from a

selling to a buying posture almost overnight, and then back to selling again.

USE OF MINERALS FOR ATTAINING POLITICAL OBJECTIVES

The Soviet Union views the export of its raw materials as not only an economic but also a political tool. It has directed its exports to those countries where it thought there were political gains to be made. Thus petroleum was a very important instrument in not only the displacement of U.S. oil interests from Cuba, but also in enhancing Soviet political objectives as well. It has apparently tried the same approach with other countries.

The Soviet Union also appears to have used its own imports as a *foreign policy tool*. Despite raw material surpluses of its own, the Soviets in the past have come to the economic aid of countries like Cuba or Iraq when the NATO powers threatened to boycott their sugar or oil. The Soviets readily purchased products and provided technical assistance to the countries being boycotted, both to supplement and to replace the assistance of the Western powers.

The U.S.S.R. grants economic, scientific, and technical aid for mineral development to 90 Asian, African, and Latin American countries. Such aid has included exploration carried out by Soviet geologists in Afghanistan, Algeria, and Malagasy, the latter as part of a contract signed in

1978. Aid has been provided to Egypt, Guinea, India, Turkey, and Yugoslavia for bauxite and alumina projects. The Soviet Union is also developing phosphate in Morocco, has built steel plants for Algeria, India, Pakistan, Iran, and Turkey, and has assisted Bolivia in building a tin smelter. While political considerations appear to be an important consideration in granting such aid, these programs have also developed sources of mineral supplies for the U.S.S.R.

When the political occasion has called for it, the Soviet Union has expressed displeasure or punished a country by restricting exports to that country in disregard of contracts and economic commitments. In 1948 Yugoslavia's oil imports from the Soviet Union were halved and eventually terminated. Similarly, the oil shipments to Israel were suspended after Israel invaded the Sinai in 1956. China, which from 1955 to 1961 was the Soviet Union's largest purchaser of petroleum, found its imports cut back sharply in 1956 and severed entirely when the Soviet and Chinese dispute intensified. Oil shipments to Finland were halted after the 1958 elections until a government more to the Soviets' liking was installed.

Despite political considerations, there are times when the Soviets have taken advantage of lucrative economic opportunities. During the Yom Kippur War and the subsequent oil embargo of the West (especially of the United States and the Netherlands) imposed by the Organization of Arab

Petroleum Exporting Countries (OAPEC), the Soviet Union increased its petroleum exports.

Emphasis on the political importance of Soviet behavior may also have affected the way in which Soviet pricing policies are viewed. Based on Soviet behavior in the late 1950's and 1960's, one would assume that the primary Soviet aim is market disruption and price cutting. Occasionally this is an accurate characterization, but for the most part the Soviets seem to follow a policy of extracting the highest possible prices. However, to gain and keep a foothold in a market, the Soviet Union often has resorted to price cutting for a while. This is perhaps best illustrated by entry of the U.S.S.R. into the U.S. chromite market in the early 1960's in competition with Turkey. Once entry is achieved, they appear to sell raw materials at market prices. They appear to cooperate with the De Beers diamond cartel by marketing a major part of their exports through this group. In the gold market, although the U.S.S.R. may have attempted to raise the price of gold by cutting back on sales, foreign exchange requirements--particularly for purchases of grain from the West--have sometimes forced Soviets to sell gold during periods of falling or depressed gold prices.

The above material was extracted from the Bureau of Mines publication, The Nonfuel Mineral Outlook For the U.S.S.R. through 1990.

Appendix D: Interviewee Questions

In our study we are trying to assess the impact on the industrial base due to a prolonged interruption in the supply of strategic and critical materials and make recommendations for a longterm solution to the problem. We hope to accomplish this by soliciting answers to the following questions from upper management in industry.

1. What would the impact on your company be if the supply of strategic materials were cut off due to political unrest or war in the countries that supply these materials?

2. What do you think should be done to minimize the effect on the defense industrial base if the U.S. supply of imported strategic and critical materials is cutoff for an indefinate period of time?

3. How long would your company be able to perform defense contracts if the supply of strategic and critical materials were cutoff for an indefinate period of time? Primarily interested in the following materials: chromium, cobalt, manganese, and titanium.

4. What plans does your company have to mitigate the effects of a strategic and critical materials cutoff? Primarily interested in the following materials: chromium, cobalt, manganese, and titanium.

5. In what ways do you think the government could encourage your company to stockpile strategic and critical materials?

6. Who are your primary suppliers of these materials?

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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) AFIT/GLM/LSM/84S-40	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION School of Systems and Logistics 6b. OFFICE SYMBOL (If applicable) AFIT/LS	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State and ZIP Code) Air Force Institute of Technology Wright-Patterson AFB, Ohio 45433	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State and ZIP Code)	10. SOURCE OF FUNDING NOS. PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT NO.
11. TITLE (Include Security Classification) See Box 19	

12. PERSONAL AUTHOR(S) Terrence P. Long, B.S. Captain, USAF
Tommy J. McClam, B.S. Captain, USAF

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
MS Thesis	FROM ______ TO ______	1984 September	160

16. SUPPLEMENTARY NOTATION

Approved for public release: IAW AFR 190-17.
Lynn E. Wolaver 14 Sept 84
LYNN E. WOLAVER
Dean for Research and Professional Development
Air Force Institute of Technology (ATC)
Wright-Patterson AFB OH 45433

17. COSATI CODES		
FIELD	GROUP	SUB. GR.
11		

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Chromium, Cobalt, Manganese, Titanium, Stockpile, Critical Materials, Strategic Materials

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Title: STRATEGIC MATERIALS: A CRISIS WAITING TO HAPPEN

Thesis Chairman: William C. Pursch, PhD

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL William C. Pursch, PhD	22b. TELEPHONE NUMBER (Include Area Code) 513-255-3944 22c. OFFICE SYMBOL AFIT/LSP

DD FORM 1473, 83 APR   EDITION OF 1 JAN 73 IS OBSOLETE.

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SECURITY CLASSIFICATION OF THIS PAGE

The United States is dependent on foreign sources for many strategic materials vital to its survival and national security. This study reviews past and present policies on the stockpiling of strategic materials, the quality of stockpiled materials, and examines the position and role of the Soviet Union in denying the U.S. access to strategic materials. It provides a close examination of cobalt, chromium, manganese, and titanium, their importance to the defense industry and the possible impact of a materials shortage on the U.S. economy and national security. To reduce America's vulnerability, a policy that integrates strategic materials, national security, foreign policy, and economic issues should be implemented. Specific findings and recommendations are presented at the end of the study.

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